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THE ARTILLERIST'S MANUAL,

AND

BRITISH SOLDIER'S COMPENDIUM.

By MAJOR F. A. GRIFFITHS,

R. F. P. ROYAL ARTILLERY.

> "Si quid novisti rectius istis,
> Candidus imperti: si non, his utere mecum."

EIGHTH EDITION.

Published by Authority.

LONDON:
W. H. ALLEN & Co., LEADENHALL STREET;
PARKER & SON, 445, WEST STRAND; CLOWES & SONS, CHARING CROSS;
SIMPKIN, MARSHALL, & Co., STATIONERS' HALL COURT;
J. BODDY, WOOLWICH.
1859.

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PREFACE.

EIGHTH EDITION.

IN order to keep pace with the numerous improvements in the science of warfare, in each edition of "THE ARTILLERIST'S MANUAL, AND BRITISH SOLDIER'S COMPENDIUM," a considerable quantity of new matter has necessarily been published; many of the subjects being also revised, and altered. Even the last edition of "The Artillerist's Manual, &c.," may in fact be deemed almost obsolete, the present compilation containing selections from the following original, or revised Works:—

1. The Infantry Manual.
2. Field Exercise, and Evolutions of Infantry.
3. Bayonet Exercise.
4. Instruction of Musketry.
5. Cavalry Sword Exercise.
6. Carbine Exercise.
7. Pistol Exercise.
8. Lance Exercise.
9. Carbine Exercise, Royal Artillery.
10. Service, and Management of Ordnance.
11. Veterinary Directions.
12. Instructions for the Exercise of great Guns on board Her Majesty's ships.

Additions, and Alterations will also appear in the following subjects; viz.:—

Additions.

Loading with blank Cartridges.
Detail of 9-Pounder Battery, R.H.A. Home establishment.
„ 6-Pounder Battery, R.H.A. Do. Do.
Distribution of a 9-Pounder Field battery, R.A. Home establishment.
Ordnance. Ammunition. Ranges, &c.
Carriages. Axletrees.
Powder cases.
Tangent scales; Land service, Sea service.
Ranges, Sea service.
Batteries. Sap roller, &c.

Tackles. Girders.
Artillery service, EAST INDIAN.
Fireworks.
Gravity.
Trigonometry.
Reconnoitring, &c.

Alterations.

Percussion Small arms.
Manufacture of Cartridges.
Instructions for browning Gun barrels.
Ordnance, length, weight, calibre, &c.
Carriages. Field, travelling: Siege, travelling: Garrison.
Carts. Waggons. Wheels. Platforms.
Cartridges for Guns, Howitzers, &c.
Stores. Combustibles, &c.
Diameter of each Shot, and Shell in the Service.
Common case, and Grape shot.
Field battery Exercise.
Detail of Field batteries. War establishment.
Do. Do. Home establishment.
Veterinary directions.
Field fortification.
Naval gunnery.
Fireworks.

Unaided by the Military, and Naval authorities, &c., it would have been impossible for me to have rendered "The Artillerist's Manual and British Soldier's Compendium" complete, and adapted for all branches of the Services, and I gratefully acknowledge my obligations to—

The Adjutant-General to the Forces.
The Deputy Adjutant-General Royal Artillery.
The Officers of the Manufacturing Departments, Royal Arsenal.
The Principal Veterinary Surgeon.
The Secretary to the Admiralty.
The Military Secretary to Government, India.
The Inspector-General of Ordnance, &c., Bombay.

As well as to many other official Friends, who have afforded the information I needed.

To this let me add the advantages I possess in having, for a coadjutor, my youngest son, who, being in the same Corps as myself, and having served in the Crimea, is enabled materially to assist in rendering the Manual acceptable to our brother officers.

Being desirous that "The Artillerist's Manual, &c.," should become more generally useful in India, an application was made for information on the subjects contained in Part X.; and deeply indebted am I to the Inspector-General of Ordnance, and Magazines, Bombay, for the valuable additions furnished from his office, which will, I doubt not, be most acceptable to the officers of the East Indian Army.

The original Compilation (in 1839) was undertaken chiefly for the use of the Non-commissioned officers of the Royal Artillery; since which period the Work has been very much enlarged, and has been favourably received by all ranks throughout the Army, having finally obtained the gracious approval of His Royal Highness the General Commanding-in-Chief:* moreover the officers of the Navy cordially welcome "The Artillerist's Manual, &c.," and copies are ordered to be included in the libraries of all vessels of war.

Thus encouraged every endeavour has been made satisfactorily to complete the Work not only as a MANUAL for the Artillery, but also as a COMPENDIUM for the use of all ranks of the United Services of the British nation.

F. A. GRIFFITHS.

Putney, August 6th, 1859.

(Copy.)

Horse Guards,

* *Memorandum.* 13*th October*, 1856.

His Royal Highness, the General Commanding in Chief, strongly recommends to the Officers, and Non-commissioned Officers of the Army, the Revised edition of a Work, entitled "THE ARTILLERIST'S MANUAL, AND BRITISH SOLDIER'S COMPENDIUM," a work replete with the most useful Military information, and of which Major Griffiths, R.F.P., Royal Artillery, is the author.

By command of

His Royal Highness,

The General Commanding in Chief,

(Signed) G. A. WETHERALL,

Adj.-General.

*** With reference to the foregoing *Memorandum;* Copies will be supplied, for the special use of Non-commissioned Officers, at the reduced rate of Five Shillings per Copy, on applications (addressed to MAJOR GRIFFITHS, Putney) by Officers Commanding regiments, detachments, &c.

PUBLICATIONS,

referred to, or extracted from.

The Infantry Manual.	
Field exercise, and Evolutions of Infantry.	
Bayonet exercise.	
Instruction of Musketry.	
Cavalry Sword exercise.	
Carbine exercise.	
Pistol exercise.	
Lance exercise.	
Carbine exercise. Royal Artillery.	
Field Battery exercise.	
Service, and management of Ordnance.	
Veterinary directions.	
Instruction for the exercise of great guns on board Her Majesty's Ships.	
Naval Gunnery	Lieut.-General Sir H. Douglas, Bart.
Bombardier, and pocket Gunner.	
Artillery	Mr. J. Landmann.
Fortification	Lieut.-General Sir C. Pasley, K.C.B. Mr. Landmann. Mr. Lochée. General Malorti. Colonel Sir J. Jebb, K.C.B. Captain Macaulay.
Military Surveying, &c. . .	Lieut.-Colonel Basil Jackson.
The Horse, with a Treatise on draught.	
Artificial Fireworks . . .	Mr. G. Mortimer.
Mathematics	Dr. Hutton. Dr. O. Gregory. Mr. Trotter.
Practical Geometry . . .	Mr. Landmann.
Natural Philosophy . . .	Dr. Fergusson.
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THE
ARTILLERIST'S MANUAL,
AND
BRITISH SOLDIER'S COMPENDIUM.

PART I.

FIELD EXERCISE, AND EVOLUTIONS OF INFANTRY.

PERCUSSION SMALL ARMS.

1. Artillery Carbine: 1853 Pattern.

Barrel	Length	2 feet.
	Diameter of bore	·577 in.
Carbine	Length	3 ft. 4½ in.
	Weight	6 lb. 7½ oz.
Sword Bayonet beyond muzzle	Length	1 ft. 10¾ in.
	Weight	1 lb. 12 oz.
Arm complete with bayonet	Length	5 ft. 3 in.
	Weight	8 lb. 3½ oz.

The Rifling is 3 grooves and one turn in 6 ft. 6 in.

Bullet	Weight	530 gr.
	Diameter	·568 in.

Charge of Powder, 2 drams F. G.
Weight of 20 Rounds, with 25 Caps = 1 lb. 11 oz. 2 drams.

2. Enfield Rifle—Musket: 1853 Pattern.

Barrel	Length	3 ft. 3 in.
	Bore	·577 in.

Three grooves, one turn in 6 ft. 6 in.

Musket	Length	4 ft. 7 in.
	Weight	8 lb. 8 oz.
Bayonet	Length beyond muzzle	1 ft. 5½ in.
	Weight	11 oz.
Complete with Bayonet	Length	6 ft. 0½ in.
	Weight	9 lb 3 oz.
Bullet	Weight	530 gr.
	Diameter	·55 in.

Charge, 2½ drams F. G.
Sixty Rounds and 75 Caps = 5 lb. 8 oz. 4 drams.

3. Victoria Carbine: (For Cavalry.)

Barrel	Length	2 ft. 2 in.
	Bore	·733 in.
Bullet (Spherical)	Weight	490 gr.
	Diameter	·689 in.

Charge, 2½ drams F. G.

Arm complete	Length	3 ft. 6 in.
	Weight	7 lb. 9 oz.

4. Sharp's Breech Loading Cavalry Carbine. (Long.)

Barrel	Length	21½ in.
	Bore	·577 in.

Number of grooves, 3 spiral, 1 turn in 6 ft. 6 in.

Bullet (Pritchett's)	Weight	530 gr.
	Diameter	·568 in.

Charge, 2½ drams.

Arm complete	Length	2 ft. 11 in.
	Weight	7 lb. 6 oz.

5. Sharp's Breech Loading Cavalry Carbine. (Short.)

Barrel	Length	19·15 in.
	Bore	·577 in.

Number of grooves, 3 spiral, 1 turn in 6 ft. 6 in.

Bullet (Pritchett's)	Weight	530 gr.
	Diameter	·568 in.

Charge, 2½ drams.

Arm complete	Length	3 ft. 1½ in.
	Weight	7 lb. 9 oz.

6. Cavalry Pistol. (à Tige.)

Barrel	Length	10 in.
	Bore	·577 in.

Number of grooves, 5 spiral, 1 turn in 6 ft. 6 in.
Charge, 1 dram.

Bullet	Weight	390 gr.
	Diameter	·568 in.
Arm complete	Length	15¾ in.
	Weight	3 lb. 3½ oz.

7. Naval Rifle.

1842 Pattern. Percussion musket, Rifled with 3 or 4 grooves.

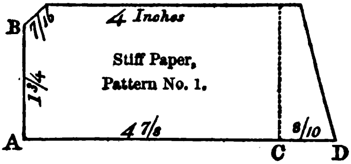
Bullet with iron cup	Weight	848 gr.
	Diameter	·746 in.

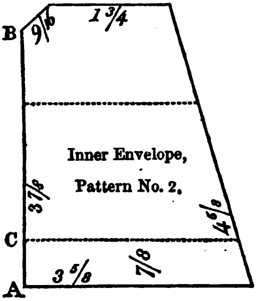
Charge, 3 drams F. G.

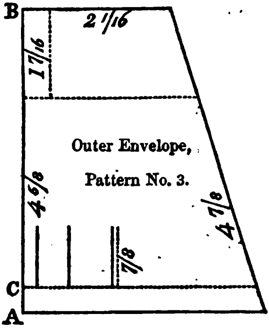
MANUFACTURE OF CARTRIDGES.

1. Every recruit is to be instructed in the method of manufacturing cartridges for his rifle in the following manner :—

2. Having cut the paper according to the size and patterns shown in plate, for cartridges for the rifle-musket or carbine,—







1. *Form the powder-case.* Roll the stiff paper, pattern No. 1, tightly about 2½ times round the "mandrel," which is to be laid on the side opposite the acute angle, or AB, with its base coincident with the broader side, or AD; then place the "inner envelope" paper, pattern No. 2, on the top of the stiff paper, with the side opposite the acute angle, or AB, of the former about ¾ of an inch from the acute angle, or CD of the latter, and roll said envelope tightly on the stiff paper and mandrel; after which slightly twist the end that overlaps about ⅞ of an inch, or AC, and fold it into the

hollow at the base of the mandrel, making use of the point of the "former," to close the folds and adapt the paper to the cavity, which is to receive the point of the bullet, being careful to secure the bottom of powder-case, so that no powder can escape therefrom.

2. *Unite the bullet with the powder-case.* Put the point of the bullet well into the cavity of the powder-case, and place both so fixed on the side of "outer envelope" paper, pattern No. 3, opposite the acute angle, or AB, and about ½ an inch from the broader side, or AC; roll the "outer envelope" tightly round bullet and powder-case with the mandrel still in it, then twist or fold the paper that overlaps, and tie it as close as possible to the base of the bullet; after which place the base of the cartridge on the table, and withdraw the mandrel with care, by pressing the powder-case with one hand while raising the mandrel with the other, so as not to separate the powder-case from the bullet, both of which must be kept as close as possible to prevent any play at the juncture, which would soon render the cartridge unserviceable.

3. *Charge the powder-case.*—Place a funnel into the mouth of the powder-case and pour 2½ drams of powder (represented by sand) or a less quantity, according to the arm used, into it; remove the funnel, being careful that none of the powder or sand escapes between the inner and outer envelopes; and secure the charge by squeezing the tops of the two envelopes close to the stiff paper of powder-case, and giving them a slight twist with a pressure inwards, laying the ends on the side of the cartridge.

   The slits in the outer envelope are made to facilitate its detachment from the bullet when fired.

4. *Lubricate the cartridge.*—The cartridge being completed, dip the base up to the shoulder of the bullet, into beeswax, melted.

LOADING WITH BLANK CARTRIDGES.

Blank cartridges are composed of the same number of parts as the Service ball cartridge, viz., an inner bag, containing the powder, a mock bullet consisting of a paper bag, with a muslin bottom filled with fine-grain powder, and an outside bag to contain both. In order to insure the flash of the discharge igniting the powder in the mock bullet, and to prevent its being projected from the musket *entire*, a portion of the bottom of the outside bag is cut away. The operation of loading with the blank cartridge is to be performed in exactly the same manner as with the ball cartridge. Care must be taken that the cartridge is *reversed* after the powder is poured into the barrel, and that the mock bullet, which occupies the portion covered with beeswax, is *alone* rammed home upon the powder, the empty powder-bag being detached in the usual way before the ramrod is inserted.

SMALL ARM AMMUNITION.

Dimensions of Boxes.

Length, 1 ft. 4 in. including the cleat. Depth, 8⅝ in. Breadth, 7¼ in.

Weight of Boxes.

Empty, 7 lb. 6 oz.

Contents and Weight of Barrels, and Boxes.

	Barrel.				Box.			
	No. of Cartridges.	No. of Caps.	Weight filled.		No. of Cartridges.	No. of Caps.	Weight filled.	
			lb.	oz.			lb.	oz.
Rifle Musket, Pattern 1842	500	625	79	0	..	..	..	
Rifle Musket, ,, 1853	700	875	73	8	560	700	60	6
Artillery Carbine . . .	800	1000	81	8	660	825	63	0
Victoria Carbine . . .	700	875	69	0	600	750	60	8

INSTRUCTIONS FOR BROWNING GUN BARRELS.

The following ingredients for the browning of arms are to be mixed, and dissolved in one gallon of soft water, viz.:—

6 ounces of Spirits of wine
6 ,, ,, Tincture of steel
2 ,, ,, Corrosive sublimate
6 ,, ,, Sweet spirits of nitre
3 ,, ,, Nitric acid

The mixture is to be kept in glass, not in earthenware, bottles.

Previous to commencing the operation of browning, it is necessary that the barrel should be made quite bright with emery or a fine smooth file (but not burnished), after which it must be carefully cleaned from all greasiness; a small quantity of pounded lime rubbed well over every part of the barrel is best for this purpose: a plug of wood is then to be put into the nose of the barrel, and the mixture applied to every part with a clean sponge or rag. The barrel is then to be exposed to the air for twenty-four hours; after which it is to be well rubbed over with a *Steel scratch-card*, or *Scratch-brush*, until the rust is entirely removed; the mixture may then be applied again, as before, and in a few hours the barrel will be sufficiently corroded for the operation of scratch-brushing to be repeated. The same process of scratching off the rust and applying the mixture is to be repeated twice or three times a day for four or five days, by which the barrel will be made of a very dark-brown colour.

The barrel is then to be exposed to the air in a warm room for twelve hours, after which time it is to be well rubbed over with a hard hair-brush, or armourer's brush, until the rust is entirely removed. The mixture is then to be applied again in the same manner as before, and in six hours the barrel will be sufficiently corroded for the operation of scratch-brushing. The process of scratching off the rust and applying the mixture is to be repeated twice or three times a day for four or five days, by which time the barrel will be of a dark-brown colour.

The rust which is raised by each successive application of the mixture is always to be removed at first with the hair-brush previously to using the scratch-card, as the latter is otherwise found to remove the browning. The operation of scratch-carding is only to commence after the second application of the mixture.

When the barrel is sufficiently browned, and the rust has been carefully removed, it is to be placed in boiling water for three or four minutes, in order that the action of the acid mixture may be destroyed and the rust prevented from rising again. The barrel while warm is to be rubbed over with sweet oil, or common olive oil. The operation for browning should be conducted in a dry and warm room; a temperature of about 70 degrees is the most favourable. The locks are on no account to be made of the hardening colour, as the repetition of the operation of hardening has a very injurious tendency.

FIELD EXERCISE, AND EVOLUTIONS OF INFANTRY.*

MARCHING.

PART I.—*S.* 7. *Length of Step.*

In slow or quick time the length of a pace is 30 inches, except in "stepping out," when it is 33 inches, and in "stepping short" 10.

In "double time" the length of the pace is 36 inches.

The length of the side step, which is always taken in quick time, is 10 inches.

N.B. When a soldier takes a side pace to clear or cover another, as in forming four deep, which will be hereafter described, the pace will be 21 inches.

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* *Note.* In consequence of the limited size of this Manual, extracts only have been taken from "THE FIELD EXERCISE AND EVOLUTIONS OF INFANTRY," the matter selected being that generally required in the field.

The PARTS and SECTIONS are numbered in conformity with the authorized publication.

In stepping back the pace is 30 inches.

S. 8. *Cadence.*

In slow time	75 steps	62 yards	18 inches	are taken
In quick time	108 ,,	90 ,,	— ,,	in a
In double time	150 ,,	150 ,,	— ,,	minute.

S. 41. *Open order from the Halt.*

†Rear rank, take open order, March—Rear rank, dress—Eyes, front—Rear rank, take close order, March.

S. 44. *Open order on the March.*

†Rear rank take open order—Rear rank take close order.

S. 57. *Breaking off Files.*

†Three files on the left, to the right-turn—Left-wheel.

The front of the Squad may be further reduced by any number of files; suppose Two:

†Two files on the left, to the right-turn—Left-wheel.

Any number of Files that have been broken off may be again ordered to the front; suppose Three:

†Three files to the front—Two files to the front.

All the Files may be brought to the front at once by the Words—

†Files to the front.

FUNERALS.

Part VI.—*S.* 21. *Directions for Funeral parties.*

The escort will be drawn up two deep, with opened ranks and unfixed bayonets, facing the house, or marquee, where the corpse is lodged; when it is brought out, the officer commanding will proceed as follows:—

Present arms—Reverse arms—Rear rank take close order, March—By Companies (or Sub-divisions), Left wheel, or on the Right backwards wheel—Quick march—Halt—Dress—Rear rank take open order—March—To the left—Face—Slow—March.

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* *Words of Command and Directions:—*

The Commander's words are printed in	Small Capitals.
The Executive words, &c. . . . . †	Small Print.
The Directions, &c.	*Italics.*

The remainder of the procession will be thus formed:—

THE CORPSE.

Pall-bearers on each side of the corpse.
Chief mourners.
Officers, or Non-commissioned officers, two and two, according to rank, the juniors in front.

When the head of the procession arrives near the spot where it is to meet the Clergyman—

Companies (or Sub-divisions) left turn, right wheel—Halt—Ranks inwards face—Front rank four paces step back—March—Rest upon your arms reversed—Stand at ease.

The Corpse having passed through—

Attention—Reverse arms—Ranks, right and left face—Slow march—Halt—Front, *when near the grave and facing towards it*—Rest on your arms reversed—Stand at ease.

The Funeral service will be performed, after which—

Attention—Present arms—Shoulder arms—With blank cartridge, load—Fire three volleys in the air—Ready—Present—Load.

After firing Three rounds the men will be directed to "Order arms—Fix bayonets—Shoulder arms," and the ranks will be closed. The escort will then be marched back to camp, or barracks, in fours, sub-divisions, or sections, right in front, in quick time.

S. 22.

MANUAL, AND PLATOON EXERCISES.

The Manual exercise for Troops armed with Long Rifles.

Words of command.

†1. Secure, arms—Two—Three.
2. Shoulder, arms—Two—Three.
3. Order, arms—Two—Three.
4. Fix, bayonets.
5. Shoulder, arms—Two.
6. Present, arms—Two—Three.
7. Shoulder, arms—Two.
8. Port, arms—Two.
9. Charge, bayonets.
10. Shoulder, arms—Two.
11. Advance, arms—Two—Three.
12. Order, arms—Two—Three.
13. Advance, arms—Two.

Words of command.

14. Shoulder, arms—Two—Three.
15. Support, arms—Two—Three.
16. Stand, at ease.
17. Attention.
18. Carry, arms—Two—Three.
19. Slope, arms.
20. Stand, at ease.
21. Attention.
22. Carry, arms—Two.
23. Order, arms.
24. Unfix, bayonets.
25. Stand, at ease.

S. 23. The Manual exercise for Troops armed with the Short Rifle.

† 1. Secure, arms—Two.
2. Shoulder, arms—Two.
3. Order, arms—Two.
4. Fix, swords.
5. Shoulder, arms—Two.
6. Present, arms—Two—Three.
7. Shoulder, arms—Two.
8. Port, arms—Two.
9. Charge, swords.
10. Shoulder, arms—Two.
11. Slope, arms—Two—Three.
12. Stand, at ease.
13. Attention.
14. Carry, arms—Two—Three.
15. Order, arms.
16. Unfix, swords.
17. Stand, at ease.

The foregoing exercise is applicable for Serjeants, and supersedes the "Fusil exercise."

S. 26. The Platoon exercise, and different Firings for the Long and Short Rifle.

† Platoon exercise by motions, standing.

1. Prepare to load—Two.
2. Load—Two—Three—Four—Five.
3. Rod—Two.
4. Home—Two—Three—Four.
5. Return—Two.
6. Cap—Two—Three—Four—Five—Six.
7. As a Front or Rear rank, at yards—Ready.
8. Present — Two—Three—Four—Five.
9. Load.

From the Capping position.

† Shoulder, arms—Two.
Advance, arms, or Shoulder, arms, with short Rifle—Two.
Order arms.

To "Order arms" from the position of "Prepare to load."

† Order arms.

TO LOAD, AND FIRE KNEELING.

† Platoon exercise by Motions, as a front (or rear) rank, kneeling.
Prepare to load—Two—Three—Four.
Load. Rod. Home. Return—Two.
Cap—Two—Three—Four—Five—Six.
As a front (or rear) Rank at yards—Ready.
Present—Two—Three—Four—Five.
Load.

From the Capping position, kneeling.

† Shoulder, arms—Two.
Advance, arms (or Shoulder, arms, with Short rifles)—Two.
Order, arms.

Troops armed with the Short Rifle will always fire Front rank kneeling.

S. 27. REVIEW EXERCISE.

† Platoon exercise in Slow time.
Prepare to load. Load. Rod. Home. Return. Cap.
Fire a volley at yards—Ready. Present.
In Quick time, load—Shoulder, arms.
Company (Right wing, or Battalion) "Fire a volley"
At yards—Ready. Present. Cease firing. Half-cock arms.

When it is not intended to reload after firing—

† Fire a volley, and shoulder—At yards—Ready.

When a Column, or Line is required to load—

† With—Cartridge (or, as with Cartridge)—Load.

FIRINGS.

S. 28. INDEPENDENT, OR FILE-FIRING.

†File-firing, from the right (or left, or from both flanks) of Companies. Commence firing—Cease firing.

S. 29. EXERCISE TO RECEIVE CAVALRY.

†Prepare to resist Cavalry—Ready—Commence firing from the right (or left, or from both flanks) of Faces—Cease firing.

Kneeling ranks (or Front face, &c., as the case may require)—Fire a volley.

At yards, Ready—Present—Load.

In squares of two deep, the front rank only will kneel to resist Cavalry.

S. 30. TO FIRE A FEU DE JOIE.

The Line drawn up at open order, with shouldered arms, and bayonets fixed.

†With blank cartridge—Load—Ready—Present.

The right-hand man of the front rank commences the fire, which will run down the front, and up the rear, as quick as possible. When the right-hand man of the rear rank has fired, the whole will glance their eyes to the right to bring the firelock to the capping position, and from thence to the loading position, and when loaded and capped they will remain steady, waiting for the words—

†Ready, Present.
Shoulder, arms—Present, arms.
Shoulder, arms—Order, arms—Three cheers.

When Artillery are present, and are ordered to fire twenty-one guns, seven will be fired before each round of the Feu de joie.

INSPECTION OF ARMS, &c.

S. 31. *Manner of inspecting a Company on parade.*

†Attention—Fix, bayonets—Shoulder, arms—Rear rank take open order—March—Port, arms—Half-cock, arms—Shoulder, arms—Order, arms—Examine, arms—Rod—Home—Return.

An inspection of the Appointments, Clothing, &c., is now to be made.

†Unfix bayonets—Rear rank, take close order, March—Stand at ease.

BAYONET EXERCISE.

SECTION 1. As soon as the Recruit is sufficiently instructed in "Marching; the Facings, &c.; Shoulder arms; Port arms; and Charge bayonet" of "the Manual exercise," Squads (not exceeding sixteen men) may fall in with shouldered arms in single rank, and close files, and be formed in two ranks for Drill practice, by the following "*words of command.*"

†Prepare for Bayonet exercise—Quick march. Port arms. Charge bayonet. Slow time. Second position. Third position. Second position. Advance. Retire. Double advance. Double retire. First position. Shoulder arms. Order arms. Stand at ease.

SECTION 2. After coming to † "Attention," "Shoulder arms," "Port arms," and "Charge bayonet" (as before), the Drill is resumed by—

†Drill practice. Guard. Balance arms. As you were. Slow time. Point—Two. Low. Point—Two. High. Point—Two. Shorten arms. Point—Two. Second point. Point—Two. Guard. Shoulder arms. Order arms. Stand at ease.

SECTION 3. On resuming the Drill, as pointed out in the previous Section, it proceeds with—

†Guard—Variations of the Point—Right—Left—Low—High—Right—Low—Guard.

SECTION 4. The preceding Practices should be performed with the right shoulder and foot to the front; for which purpose the Squad, being brought to the position of "Guard," the command is given—

"About."

The whole of the preceding Practices are then to be gone through by the same words of command, and the Squad is brought to its proper front from the position of "Guard," as follows—

†About. Shoulder arms. Order arms. Stand at ease.

SECTION V.—REVIEW EXERCISE.

The Company or Battalion being in Line at "Shoulder arms" and closed ranks, the command is given—

†Prepare for Bayonet exercise. Quick march. Review exercise—Guard. Point—Low. Point—High. Point. Shorten arms. Point. Second point—Point. Guard—Right. Point—Left. Point—Low. Point—High. Point—Right. Point—Low. Point. Guard. Shoulder arms. Order arms. Stand at ease.

The above movements are then to be gone through with the right shoulder and leg forward, the command "About" being given from the position of "Guard," by following the instructions laid down in the preceding Section; and on the Exercise being finished, the Company or Battalion (after coming to the "Shoulder arms") is re-formed "Two deep" by the command, "Form line—Quick march"—"Stand at ease," as hitherto directed.

SECTION VI. ATTACK, AND DEFENCE AGAINST THE SWORD.

For this purpose a Squad (in two ranks) is formed and extended, so that the Files are two paces apart, with an interval of three paces between the ranks, the front rank having the swords.

The Front rank being at "Slope swords," and the Rear rank at "Shoulder arms," the command is given—

†Front rank—Right about face. Guard. Prove distance—Two. Point—Point—Point—Point—Point—Point—Point. Shoulder arms.

Continuation of the "Attack and defence" between the two weapons, as follows, but first in two motions—

† Guard. Point—Two. Guard—Point. Guard—Point. Guard. Shoulder arms.

INFANTRY SWORD EXERCISE.

Words of command throughout

THE PROGRESSIVE INSTRUCTIONS OF THE DRILL.

The words in Italics are to serve as a Caution only.

SECTION I.

EXTENSION MOTIONS, AND POSITIONS.

Attention.

First extension motions.—One—Two—Three—Four—Five.
First position in three motions.—One—Two—Three.
Second position in two motions.—One—Two.
Balance motions.—One—Two—Three—Four.
First position.
Third position in two motions.—One—Two.

Second extension motions.—One—Two—Three.
First position.
Front.
Stand at ease.
Attention.

Positions.

First—Second—First—Third.
First—Second—Third—Second.
Single attack—Double attack.
Advance—Single attack—Retire—Double attack.
Front—Stand at ease.

SECTION II.

PREPARATORY INSTRUCTION WITH THE SWORD.

Attention.
Draw swords—Return swords—Draw swords—Slope swords.
Stand at ease.

Attention.
Prepare for Sword exercise.
Right prove distance—Slope swords.
Front prove distance—Slope swords.
Assault.
One—Two—Three—Four—Five—Six—Seven.
First Point—Two—Second Point—Two—Third Point—Two.
Defend.
Second—Third—Fourth—Fifth—Sixth—Seventh.
Parry—Two. Slope swords. Stand at ease.
Attention.

Guard—Inside guard—Outside guard.

Cut one.	First guard.
Cut two.	Second guard.
Cut three.	Third guard.
Cut four.	Fourth guard.
Cut five.	Fifth guard.
Cut six.	Sixth guard.
Cut seven.	Seventh guard.
First point.	Two.
Second point.	Two.
Third point.	Two.
Parry.	Two.
Guard.	Slope swords.

Stand at ease.

SECTION III.

REVIEW, OR INSPECTION EXERCISE.

Attention.
Prepare for Sword exercise.
Right prove distance—Slope swords.
Front prove distance—Slope swords.
Guard—Inside guard—Outside guard.
One—Two—Three—Four—Five—Six—Seven.
Points—First—Second—Third—Parry.
Guard—Slope swords.

SWORD PRACTICE.

Guard.
Inside, and outside Cuts.—One—Two—Three—Four—Five—Six.
Inside guard.
Outside Cuts.—Two—Four—Six.
Outside guard.
Inside Cuts.—One—Three—Five.
Guard—Slope swords—Stand at ease.

SECTION IV.

ATTACK, AND DEFENCE.

Attention.
Front rank, Right about face—Prepare for Attack, and Defence.
Prove distance—Slope swords.
Guard—Inside guard—Outside guard.
Left cheek—Right cheek—Wrist—Leg.
Left side—Right side—Head.
First point—Two—Third point—Two.
Guard—Slope swords.

Point, and Parry.—Guard—Third point—Point.
Point (continuing as long as requisite).
Guard—Slope swords—Stand at ease.

SECTION V.

STICK DRILL.

First Practice.

Guard—Continuing the same words of command and movements as in the "Attack and Defence" in Section 4th, omitting the word "Two" in the delivery of each point.

Second Practice.

Guard—Continuing, &c., as the "Point and Parry," but not exceeding Six points.

Third Practice.

Guard—Leg—Inside guard—Leg.
Outside guard—Leg—Guard—Slope swords.

Fourth Practice.

Guard—Head—Head—Leg—Leg—Head—Head—Guard.
Slope swords.

Fifth Practice.

Head—Head—Arm—Head—Head—Arm.
Head—Head—Right side—Head—Head—Right side.
Slope swords.

When perfect, by Word of command, the whole of this Section is to be performed in Quick time, by the drill officer naming only the practice required, but first giving the caution—*Stick drill by practice divisions.*

PART II.—GENERAL PRINCIPLES.

VII. *Relative Proportion of Paces to Files.*

Each man occupies a space of about 21 inches; therefore, to ascertain the number of paces of 30 inches required for a given number of files, multiply the number of files by 21, and divide the product by 30; or use the multiples of these numbers, that is, multiply by 7 and divide by 10, the latter operation being accomplished by cutting off the last figure, which multiplied by 3 will designate the odd inches. It will be useful to remember, that 10 files require 7 paces, 20 files 14, and so on—one hundred files 70 paces, a thousand files 700.

A COMPANY IN LINE, AND COLUMN.

S. 1. *Formation of a Company in Line.*

Caution—AS A COMPANY IN LINE.

1. *Formation in Close order.*—On the above caution, the captain will place himself on the right of the front rank, covered by his covering serjeant, who will be on the right of the rear rank; the remaining officers and serjeants will place themselves in a third or supernumerary rank, three paces from the rear rank; the lieutenant in rear of the second file from the left, the ensign in rear of the centre of the company, the third supernumerary in rear of the left subdivision, the fourth in rear of the right, the fifth in rear of the left, and so on. When a company is formed singly, or when it is manœuvring, the drummers and pioneers will also be in the super-

numerary rank, the former in rear of the second section, the latter in rear of the third section; the lieutenant and ensign will always retain their places; the serjeants and men composing the rest of the supernumerary rank will divide the space in rear of their respective subdivisions and sections.

2. *Taking open order.*

* REAR RANK TAKE OPEN ORDER—MARCH.	* Rear rank, dress—Eyes front. Supernumerary rank, dress—Eyes front.
STEADY.	*On the word* STEADY, *the officers will port their swords.*

3. *Resuming Close order.*

REAR RANK TAKE CLOSE ORDER—MARCH.

S. 4. *Open order, on the March.*

A company in column, right in front, marching in slow time, will take open order in the manner described in Section 44, Part I. The officers will recover their swords and move out in double time to their places in front of the company, porting their swords as they take up the slow time; the captain will be in front of the second file from the right, the lieutenant in front of the second file from the left, the ensign in front of the centre, at three paces distance, as in line; the covering serjeant will move up to the place vacated by the captain, and will lead the company; the supernumerary rank will mark time three paces.

The company will resume close order in the manner described in Section 44, Part I., the officers recovering their swords, and moving to their proper places on the word ORDER, carrying their swords, and taking up the step as they arrive at their respective posts.

WHEELING FROM THE HALT.

S. 5. *A Company wheeling, from the Halt, from Column into Line.*

Caution.—AS A COMPANY IN COLUMN, RIGHT IN FRONT.

LEFT WHEEL INTO LINE—QUICK MARCH.	Company—Halt. Dress. Eyes front.

A Company in Column, left in front, will be taught to wheel into Line in a similar manner, on the Commands—

RIGHT WHEEL INTO LINE, &c.

S. 6. *A Company wheeling from the Halt, from Line into Column.*

Caution—AS A COMPANY IN LINE.

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* *Vide Note* *, *page* 7.

Open column, right in front. Right about face. Right wheel, Quick march.	Company, Halt—Front—Dress.

A Company in Line will also be taught to wheel into an open Column, Left in front, in like manner; the Company, having been faced about, will wheel to the left.

S. 7. *A Company wheeling any given number of paces, on either flank, from the Halt.*

—— Paces, right (or left)—wheel; or —— Paces on the right (or left) backward wheel. Quick march.	Halt—Dress. Eyes front.

The eighth File wheeling eight paces will complete the quarter circle, four paces the eighth of a circle, and two paces the sixteenth of a circle.

S. 8. *A Company wheeling on the Centre, from the Halt.*

On the centre, right (or left) wheel. Quick march.	Company, Halt—Dress,

S. 9. *Wheeling forward by Sub-divisions, or Sections, from Line.*

1. *Wheeling forward by Sub-divisions.*

By sub-divisions, right wheel. Quick march. | Halt—Dress.

In like manner a Company will wheel by Sub-divisions to the Left.

2. *Wheeling forward by Sections. Similar to Sub-divisions.*

S. 10. *Wheeling backward by Sub-divisions, or Sections from Line.*

1. *Wheeling back on the Left.*

By sub-divisions (or sections) on the Left backwards wheel. Quick march.	Halt—Dress.

2. *Wheeling back on the Right.* In like manner Sub-divisions, or Sections, will wheel backwards on the right.

S. 11. *On Open column of Sub-divisions, or Sections, Wheeling into Line.*

1. *A Column, right in front, wheeling to the left, into Line,*

Left wheel into line. Quick march. | Halt—Dress. Eyes front.

2. *A Column, left in front, wheeling to the right, into Line.* In like manner a Company in column of sub-divisions, or sections, left in front, will wheel into Line on the commands—Right wheel into line, &c.

WHEELING ON A MOVEABLE PIVOT.

S. 12. *Wheeling from Line into Column, and Column into Line.*

1. *From Column into Line.*

RIGHT (OR LEFT) WHEEL INTO LINE.	*While on the march.*

2. *From Line into Column.*

COMPANIES (SUB-DIVISIONS, OR SECTIONS) RIGHT (OR LEFT) WHEEL.	*While on the march.*
ON THE MOVE, BY COMPANIES, SUB-DIVISIONS, &C.	*From the halt.*

S. 13. *Columns changing direction.*

CHANGE DIRECTION TO THE RIGHT, (OR LEFT).	*Each company, &c., will wheel in succession.*

If a Company wheels the same number of paces that it contains files, it will complete the quarter circle; if half that number of paces, it will complete the eighth of a circle; and if a quarter of the number, it will complete the sixteenth of a circle.

S. 14. *The Echellon march of Sub-divisions, or Sections.*

TAKE GROUND TO THE RIGHT, (OR LEFT) IN ECHELLON. ON THE MOVE, BY SUB-DIVISIONS (OR SECTIONS) RIGHT (OR LEFT) WHEEL. QUICK MARCH.—FORWARD.

A Company on the march will take ground to a flank in echellon in the same manner, the command being "BY SUB-DIVISIONS (OR SECTIONS), RIGHT (OR LEFT) WHEEL, FORWARD.—RE-FORM COMPANY. FORWARD."

MISCELLANEOUS MOVEMENTS, AND FORMATIONS.

* *S.* 16. *A Company, in Column of Sub-divisions, (or Sections) forming to the reverse flank.*

A Company in Column of sub-divisions, right in front, will form to the Right, as follows :—

RIGHT FORM COMPANY.	Leading sub-division right wheel. Forward. Halt—Dress. Left sub-division right wheel. Forward. Halt—Dress up. Eyes front.

A Column of Sub-divisions left in front will form Company to the Left in like manner. A Column of Sections will form Company to the Reverse flank on similar principles.

* *S.* 23. *Counter-marching.*

A Company in column, right, or left in front.

COUNTERMARCH BY RANKS. RIGHT AND LEFT FACE. QUICK MARCH.	Company—Halt—Front—Dress.

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* In consequence of the limited size of this Manual, the Sections which consist chiefly of directions are necessarily omitted.

COUNTERMARCH BY FILES. TO THE RIGHT (OR LEFT) FACE. LEFT (OR RIGHT) COUNTERMARCH. QUICK MARCH.	Halt—Front—Dress.

A Company in line may also be countermarched by Files, or Ranks. When a Company is to countermarch by files, it will always be faced from the future pivot flank, and will be marched up to it. When a Company is to countermarch, and continue its march, it may move in fours.

INCREASING, AND DIMINISHING THE FRONT OF COLUMNS.

S. 24. *A Company diminishing Front, by forming Sub-divisions from the Halt.*

Caution—AS A COMPANY IN COLUMN, RIGHT (OR LEFT), IN FRONT.

Right in front.

FORM SUB-DIVISIONS. LEFT SUB-DIVISION, RIGHT ABOUT THREE-QUARTERS FACE. QUICK MARCH.	Halt—Front—Dress.

S. 25. *A Company diminishing Front by forming Sub-divisions on the march.*

Right in front.

FORM SUB-DIVISIONS.	Left sub-division—Mark time. Right half turn. Front turn.

The foregoing principles equally apply to a Company in Column, left in front, in which case the right sub-division will double in rear of the left.

S. 26. *Sub-divisions diminishing Front, by forming Sections.*

The directions that apply to the formation of Sub-divisions from a Company, apply equally to the formation of Sections from Sub-divisions: if the Company is halted, the Drill instructor will give the words—LEFT (OR RIGHT) SECTIONS, RIGHT (OR LEFT) ABOUT THREE-QUARTERS FACE, QUICK MARCH; but, if on the march, the Captain will give the words—"Left (or Right) sections, Mark time; Right (or Left) half-turn" to both Sections. The Section leaders giving the words "Halt—Front—Dress," or "Front-turn."

S. 27. *Sections increasing Front by forming Sub-divisions from the Halt.*

FORM SUB-DIVISIONS. LEFT SECTIONS LEFT HALF FACE. QUICK MARCH.	Halt — Front, Dress.

S. 28. *Sections increasing Front by forming Sub-divisions on the March.*

Right in front.

FORM SUB-DIVISIONS.	Left Sections, Left half-turn, Double, Front turn, Quick.

A Column of Sections, left in front, will form Sub-divisions in like manner, both from the Halt, and on the march.

S. 29. *Sub-divisions increasing Front by forming Company.*

The directions, that apply to the formation of Sub-divisions from Sections, apply equally to the formation of a Company from Sub-divisions.

S. 30. *Diminishing, and increasing Front by breaking off Files, and bringing them again to the Front.*

Files will be broken off, as described in Sec. 57, PART I.

S. 31. *Increasing, and diminishing Front by breaking into Fours, or Files, and re-forming Sections, Sub-divisions, or Company.*

A Company, or open Column of Sub-divisions, or Sections, right in front, may advance from the right in Files, or Fours, by the words—RIGHT FACE (or FOURS RIGHT) LEFT WHEEL, QUICK MARCH; if the Column is Left in front, the fours, or files will advance from the Left in like manner. These movements may also be done when the Column is on the march, the commands then being—FOURS RIGHT, LEFT WHEEL; FOURS LEFT, RIGHT WHEEL; or RIGHT (OR LEFT) TURN, LEFT (OR RIGHT) WHEEL.

SQUARES.

S. 32. *Forming close Column of Sections, and Company square.*

For this formation the Company will stand with fixed bayonets, and shouldered arms.

FORM CLOSE COLUMN OF SECTIONS. QUICK MARCH. PREPARE FOR CAVALRY. READY. |

The Company will be re-formed, as follows:—

RE-FORM COLUMN. RE-FORM COMPANY. QUICK MARCH. |

S. 33. *Forming Rallying Squares.*

FORM RALLYING SQUARE. THE SQUARE WILL ADVANCE (RETIRE, OR MOVE TO THE RIGHT, OR LEFT). INWARDS FACE. QUICK MARCH. |

To resist Cavalry.

HALT. PREPARE FOR CAVALRY. READY. |

When the Square is to be reduced;

| Re-form Company (Sub-division, or Section.)

PROVING.

S. 34. *Proving a Company.*

After a Company has been told off on Parade, it will be proved in the following manner:

† Mark time—Quick. Sub-divisions right wheel (*when in echellon*) Mark time. Re-form Company.

Sub-divisions left wheel. (*When in echellon*) Mark time. Re-form Company.

Sections right wheel. (*When in echellon*) Mark time. Re-form Company.

Sections left wheel. (*When in echellon*) Mark time. Re-form Company.

The Company will then be turned to the right about, and proved in the same manner, rear rank in front.

† Halt—Front.

Fours-Deep, Front.

Fours-Right, Front.

Fours-Left, Front.

Fours-About, Front.

The Company will also be proved, rear rank in front, in forming fours to the right and left on the march, as follows:

† Mark time—Quick.

Right-about—Turn.

Fours-right—Rear, Turn.

Fours-Left—Rear, Turn.

Halt—Front.

Form close column of Sections, Quick march—Re-form Company, Quick march.

Square on the leading Company, Quick march—Sections, Outwards—Re-form column—Quick march—Halt—Dress, *or according to the position it is to take in column.* See PART III., Section 44.

† Right sections, first and third, Order arms. Left sections, second and fourth, Order arms. Right sub-division, Stand at ease. Left sub-division, Stand at ease.

S. 35. *Dismissing a Company.*

To the Right face. Lodge arms. | *As described in Part* I.

PART III.—FORMATION, AND EVOLUTIONS OF A BATTALION.

A BATTALION ON PARADE.

S. 1. *Formation of a Battalion on Parade in open Column, Right in front.*

As a general rule, a battalion will assemble on parade in open column right in front; that is, the company that stands on the right when in line will be in front.

The usual post of the commanding officer in open column is on the pivot flank of the leading company; that of the senior major, two paces from the reverse flank of the centre of the right wing, and that of the second major, two paces from the reverse flank of the centre of the left wing. The adjutant, two paces from the reverse flank of the right centre company. When a column is ordered to advance, the major of the leading wing will place himself in rear of the pivot flank of the second company from the front, to superintend the direction, taking care not to get in front of the captain of the third company.

TELL OFF THE BATTALION.	No. One—Right Company. No. Two—Left Company. &c. &c. &c.

Nos. 1, 2, 3, 4, 5, Right wing. Nos. 6, 7, 8, 9, 10, Left wing. Eyes front.

S. 2. *Wheeling into Line from Open Column.*

LEFT (OR RIGHT) WHEEL INTO LINE. QUICK MARCH.	Steady. No. ——, Halt. Dress. Eyes front.

FORMATION, AND MOVEMENTS OF A BATTALION IN LINE.

S. 3. *Formation of the Battalion in Line.*

When a Battalion is formed in Line there is to be no interval between the Companies.

S. 4. *A Battalion in Line taking open order, and resuming close order.*

1. *Taking Open order.*

REAR RANK TAKE OPEN ORDER. MARCH	Eyes—front. Steady.

2. *Taking Close order.*

REAR RANK TAKE CLOSE ORDER. MARCH	

S. 5. *Advancing, and retiring in Line.*

1. *Advancing in Line.*

THE LINE WILL ADVANCE.* QUICK MARCH. BATTALION HALT.	* Steady.

2. *Retiring in Line.*

THE LINE WILL RETIRE. RIGHT ABOUT FACE. QUICK MARCH. HALT—FRONT.	

S. 6. *Charging in Line.*

PREPARE TO CHARGE. CHARGE. HALT.	

S. 7. *Dressing a Battalion in Line.*

THE BATTALION WILL DRESS BY THE RIGHT (OR LEFT). COVERERS —— PACES TO THE FRONT. QUICK MARCH.* HALT. BY THE RIGHT (OR LEFT), DRESS UP.	* Steady. No. ——, Eyes front. Steady.

S. 8. Advancing, and Retiring by Wings.

1. *Advancing, and Firing by Wings.*

THE BATTALION WILL ADVANCE AND FIRE BY WINGS.	*Junior Major.* Left wing—Ready, Present. Load. *Senior Major.* Right wing, By the left. Quick march. Right wing—Halt, &c. *Junior Major.* Left wing, Shoulder arms. By the right. Quick march, &c. *Senior Major.* Right wing—Ready, Present. Load, &c.

2. *Retiring, and firing by Wings.*

THE BATTALION WILL RETIRE, AND FIRE BY WINGS.	*Junior Major.* Left wing—Ready, Present. Load. Shoulder arms. Right about face. By the left—Quick march. Halt—Front. *Senior Major.* Right wing—Ready, Present. Load. Shoulder arms. Right about face. By the right. Quick march. Halt—Front. *Junior Major.* Left wing, Ready, &c.

S. 9. A Battalion in Line passing obstacles.

If the obstacles are small, the files whose progress is interrupted by them, will break off in the same manner as files are broken off from the flank of a Company in column. The moment the obstacle is passed, the files must move up again to the front. If a Company, or Sub-division is required to break off, it will move by Fours, or if Files break off successively till they amount to a Sub-division they will form Fours.

FROM THE RIGHT (OR LEFT) OF COMPANIES PASS BY FOURS TO THE FRONT. FOURS—RIGHT, LEFT WHEEL; OR FOURS—LEFT, RIGHT WHEEL.	*When the obstacles are such as to require all the Companies to break into Fours.*
FROM THE PROPER RIGHT (OR LEFT) OF COMPANIES PASS BY FOURS TO THE REAR. FOURS—LEFT, RIGHT WHEEL; OR FOURS—RIGHT, LEFT WHEEL.	*If all the Companies of a Battalion retiring in Line are required to break into Fours.*

S. 10. Battalions in Line relieving each other.

1. *Advancing.*

FROM THE RIGHT OF COMPANIES PASS BY FOURS TO THE REAR. FOURS—RIGHT. RIGHT WHEEL.	
QUICK MARCH. HALT—FRONT. LEFT WHEEL INTO LINE. QUICK MARCH.	Halt, Dress.

2. *Retiring.*

FROM THE PROPER RIGHT OF COMPANIES PASS BY FOURS TO THE REAR. FOURS—LEFT, &c.	

COLUMN MOVEMENTS.

S. 11. *Formation of a Battalion in Open column.*

The rules laid down for the formation of an open Column, Right in front, in PART III., Section 1, are equally applicable to the formation of an Open column Left in front.

S. 12. *Forming Close, or Quarter distance Column from any more Open column.*

1. *Closing from the Halt.*

THE COLUMN WILL CLOSE TO THE FRONT, (OR TO QUARTER DISTANCE ON THE FRONT): OR THE COLUMN WILL CLOSE TO THE REAR (OR TO QUARTER DISTANCE ON THE REAR), REMAINING COMPANIES RIGHT ABOUT FACE; OR THE COLUMN WILL CLOSE ON (OR TO QUARTER DISTANCE ON) NO. —— COMPANY. COMPANIES IN FRONT, RIGHT ABOUT FACE. QUICK MARCH.*	* No. —— Halt—Dress. No. —— Halt—Front —Dress. Steady.

2. *Formation of a Close, or Quarter distance Column.*

The arrangement of a Close, or Quarter distance Column will be the same as that of an open column, the distances only being different.

3. *A Column on the march, closing to the Front.*

When a Column on the march is ordered to close to the front, the Captain of the leading Company, on the caution, will give the words, "No. 1. Halt—Dress." The Column will then be formed as already described.

4. *Closing to the Front without Halting.*

ON THE MARCH—CLOSE TO THE FRONT (OR CLOSE TO QUARTER DISTANCE) ON THE LEADING COMPANY. REMAINING COMPANIES, DOUBLE.	No. —— Quick.

S. 13. *A Close, or Quarter distance Column opening from the Front, Rear, or from any named Company.*

1. *From the Front.*

OPEN OUT TO QUARTER (OR WHEELING) DISTANCE FROM THE FRONT.—REMAINING COMPANIES, RIGHT ABOUT FACE. QUICK MARCH.	No. —— Halt —Front—Dress.

2. *Opening from the Rear.*

OPEN OUT TO QUARTER (OR WHEELING) DISTANCE FROM THE REAR.—REMAINING COMPANIES, QUICK MARCH.	No. —— Halt. No. —— Dress.

3. *Opening from a Central Company.*

The Companies, in front and rear of the central company, will proceed as already described.

4. *Advancing in Succession from the Front.*

ADVANCE BY SUCCESSIVE COMPANIES FROM THE FRONT, AT QUARTER (OR WHEELING) DISTANCE. NO. —— QUICK MARCH.	*In succession*, No. —— Quick march.

5. *Opening on the March, without Halting.*

OPEN OUT TO QUARTER (OR WHEELING) DISTANCE FROM THE FRONT: REMAINING COMPANIES, MARK TIME.	*In succession*, Forward.

6. *Opening on the March, by Halting the rear Company.*

OPEN OUT TO QUARTER (OR WHEELING) DISTANCE, FROM THE REAR.	*Rear Company* Halt. *Movement as described from the Halt.*

S. 14. *Columns increasing, and diminishing their Front.*

When an open Column is on the march, each Company in succession, as it arrives at a narrow space or defile, will, when necessary, diminish its front; and, as each Company clears the narrow space, it must again increase its front.

S. 15. *An Open column changing direction, and marching on an alignment, or moving into an alignment by the Flank march of Fours.*

1. *Changing direction.*

A Battalion marching in Column may change direction by the successive wheel of its Companies on moveable pivots round the same point.

S. 16. *A Column at Close, or Quarter distance, Wheeling on a fixed or moveable pivot.*

1. *Wheeling on a Fixed pivot.*

COLUMN—LEFT (OR RIGHT) WHEEL. QUICK, (OR DOUBLE) MARCH. COLUMN—HALT.	

2. *Wheeling on a Moveable pivot.*

COLUMN—RIGHT (OR LEFT) WHEEL. COLUMN—FORWARD.	

S. 17. *A Close, or Quarter-distance Column taking ground to a flank, wheeling to the right, or left.*

A Column taking ground to a flank will wheel to the right, or left, on the principles laid down in the preceding Section.

S. 18. *A Close, or Quarter distance Column countermarching, by the Wheel of Sub-divisions round the Centre.*

1. *From the Halt.*

COUNTERMARCH BY SUB-DIVISIONS ROUND THE CENTRE. RIGHT (OR LEFT) SUB-DIVISIONS, RIGHT ABOUT FACE. QUICK (OR DOUBLE) MARCH.—HALT—FRONT, DRESS.

2. *On the March.*

COUNTERMARCH BY SUB-DIVISIONS ROUND THE CENTRE. RIGHT (OR LEFT) SUB-DIVISIONS—RIGHT (OR LEFT) ABOUT TURN.—FRONT TURN.

S. 19. *Columns countermarching by Files, and by Ranks.*

Open and Quarter distance columns will countermarch by files; Close columns by ranks; each company moving as described in PART II., Section 23.

S. 20. *Changing the Order of a Column, by the successive march of the rear Companies to the front.*

When Right in Front.

BY SUCCESSIVE COMPANIES, REAR WING TO THE FRONT.	*Captain of rear company.* No. —— Fours left. Quick march. Front—turn. By the right. *Captain of next company.* No. —— Fours left. Quick march. Front—turn. By the right.

The remaining Companies will successively follow in a similar manner.

When Left is in front, the Right companies will be brought to the front in a similar manner, each forming fours to the right, and coming up in succession.

S. 21. *Changing the Order of an Open, Half, or Quarter distance column, formed upon a road where the space does not admit of the flank movement.*

When right in front.

BY FOURS FROM THE LEFT, REAR WING TO THE FRONT.	*Captain of rear company.* No. —— Fours—left. Right wheel.
FOURTH SECTIONS, RIGHT WHEEL. QUICK MARCH.	Fourth section, Halt. *Captain of next company.* No. —— Fours—left. Quick march. *Captain of left company.* No. —— Front—form company.—Forward.

The remaining companies will follow in like manner. A column *Left in front* will bring its rear companies to the front by fours from the Right in a similar manner; the first sections being wheeled to the left.

S. 22. *Columns taking ground to a flank, by the Echellon march of Sections.*

When a Column is required to take ground to a flank in echellon of sections, each Company will move, as described in PART II., Section 14.

S. 23. *Columns taking ground to a flank in Fours, Sub-divisions, or Sections.*

TAKE GROUND TO THE RIGHT (OR LEFT) IN FOURS. FOURS—RIGHT (OR LEFT). (QUICK MARCH, *if halted*).	

S. 24. *Columns, when taking ground to a flank by Fours, closing to less distance, or opening out to greater distance from any named Company.*

1. *Closing to less distance.*

CLOSE ON NO. —— COMPANY; (OR CLOSE TO QUARTER DISTANCE ON NO. —— COMPANY.)— * COLUMN FORWARD.	* *When the movement is completed.*

2. *Opening out to greater distance.*

OPEN OUT TO QUARTER (OR WHEELING) DISTANCE FROM NO. —— COMPANY. * COLUMN—FORWARD.	* *When the movement is completed.*

On open ground the Companies in these movements may close, or open out by the diagonal march.

BY THE DIAGONAL MARCH, CLOSE (OR OPEN OUT), &C.—REMAINING COMPANIES—INWARDS (OR OUTWARDS) HALF TURN.	No. —— Right half turn. No. —— Left half turn.

S. 25. *Application of the Flank march of Columns by Fours.*

The flank march of Columns by Fours will be found most useful in the advance of large bodies of troops.

FORMATIONS OF COLUMN, FROM LINE.

S. 26. *A Line wheeling back into Open column from the Halt.*

1. *By Companies into Open column, Right in front.*

OPEN COLUMN, RIGHT IN FRONT—RIGHT ABOUT FACE. RIGHT WHEEL. QUICK MARCH.	Halt—Front—Dress.

2. *By Companies into Open column, Left in front.*

Open column, left in front, will be formed in like manner.

3. *By Sub-divisions (or Sections), into Column, Right in front.*

BY SUB-DIVISIONS (OR SECTIONS) ON THE LEFT BACKWARD—WHEEL.—QUICK MARCH.	Halt—Dress.

4. *By Sub-divisions (or Sections) into Column, Left in front.*

Sub-divisions and Sections will wheel back on their right in like manner.

When the Sub-divisions, or Sections, exceed twelve Files, the words of command will then be—

OPEN COLUMN OF SUB-DIVISIONS (OR SECTIONS) RIGHT (OR LEFT) IN FRONT, RIGHT ABOUT—FACE, &c., &c.

S. 27. *A Line wheeling into Open column on the march.*

BY COMPANIES (SUB-DIVISIONS, OR SECTIONS) RIGHT (OR LEFT) WHEEL.—FORWARD.

When a Battalion is required to wheel on moveable pivots from the Halt, the caution must be given thus—

ON THE MOVE BY COMPANIES (SUB-DIVISIONS OR SECTIONS) RIGHT (OR LEFT) WHEEL, QUICK MARCH.

S. 28. *A Battalion moving in Open column, from either flank, along the Rear.*

1. *By Companies from the Right.*

THE BATTALION WILL MOVE IN COLUMN OF COMPANIES, FROM THE RIGHT, ALONG THE REAR.	No. 1. Fours—Left. Left wheel. Quick march. Front turn. No. 2. Fours—Left. Left wheel. Quick march. Front turn. *Companies in succession.*

2. *By Companies from the Left.*

THE BATTALION WILL MOVE IN COLUMN OF COMPANIES, FROM THE LEFT, ALONG THE REAR.	No. ——. Fours—Right. Right wheel. Quick march. Front turn. *Companies in succession.*

S. 29. *A Battalion formed in Line, advancing from a flank, in Open column of Companies, Sub-divisions, or Sections.*

1. *Advancing from a Flank, by Companies.*

RIGHT (OR LEFT) COMPANY TO THE FRONT. REMAINING COMPANIES, ON THE MOVE, RIGHT (OR LEFT) WHEEL. QUICK MARCH.—FORWARD.	No. ——* Left (or right) wheel. Leading Company—Forward. No. ——* Forward. &c., &c., &c.

2. *Advancing from a Flank by Sub-divisions, or Sections.*

RIGHT (OR LEFT) SUB-DIVISION (OR SECTION) TO THE FRONT, REMAINING SUB-DIVISIONS (OR SECTIONS), ON THE MOVE, RIGHT (OR LEFT) WHEEL. QUICK MARCH.—FORWARD. &c., &c.

3. *Advancing from a Flank by Companies, Sub-divisions, or Sections, on the March.*

RIGHT (OR LEFT) COMPANY, (SUB-DIVISION, OR SECTION) TO THE FRONT, REMAINING COMPANIES, (SUB-DIVISIONS, OR SECTIONS) RIGHT (OR LEFT) WHEEL; &c., &c.	

S. 30. *A Battalion in Line advancing in Double column of Companies, Sub-divisions, or Sections from the Centre.*

The following description of an advance by Sub-divisions will apply equally to an advance by Companies, or Sections, with the exceptions that will hereafter be mentioned.

1. *Advancing by Sub-divisions.*

TWO CENTRE SUB-DIVISIONS TO THE FRONT, REMAINING SUB-DIVISIONS, ON THE MOVE, INWARDS WHEEL. QUICK MARCH.—FORWARD.	Left sub-division, Left wheel.* Right sub-division, Right wheel.† Two centre sub-divisions—Forward. By the left. * Forward. † Forward.

When the advance is to be in Double column of Companies, on the caution, the Captain of the left centre company only will change his flank, the remaining officers will stand fast.

S. 31. *A Battalion formed in Line, retiring over a bridge, or through a defile, or retreating from a flank, or from both flanks in Rear of the Centre.*

1. *From a Flank, by Companies.*

RETIRE BY COMPANIES, FROM THE LEFT, IN REAR OF THE RIGHT.	*Captain of Left Company.* No. —— Right about face. By the right, Quick march. Left wheel. Forward. No. —— Right wheel. Forward. By the left. *Each Company in succession* (*except the right Company*). No. —— Right about face. Quick march.—Left wheel. Forward. No. 1. Right about face. Quick march.

A Battalion will retire by Companies from the Right in rear of the Left, in like manner.

A Battalion will retire by Sub-divisions, or Sections, in the same manner as it retires by Companies; the Captain will give the words "Right about face" and "Quick march" to each of his sub-divisions, or sections; the proper leaders will then take command and give the words "Right (or Left) wheel, Forward."

2. *From both Flanks in rear of the Centre.*

The following description of the retreat by Sub-divisions will apply equally to a retreat by Companies, or Sections.

RETIRE BY SUB-DIVISIONS, FROM BOTH FLANKS, IN REAR OF THE CENTRE.	* *Two flank Sub-divisions.* Right Sub-division, Right about face. Quick march. Right wheel. Forward. Left Sub-division, Right about face. Quick march. Left wheel—Forward.
† *Captain of Left centre Company, to the two centre Sub-divisions.*	†Right about face. Quick march.
‡ *Corresponding Sub-divisions of the two Wings.*	‡Left wheel. Right wheel. Forward.

S. 32. *A Battalion in Line, forming Open, Close, or Quarter distance Column.*

1. *Forming Open, Close, or Quarter distance Column, in rear of the Right Company.*

OPEN, (CLOSE, OR QUARTER DISTANCE) COLUMN IN REAR OF NO. 1. REMAINING COMPANIES, FOURS RIGHT. QUICK MARCH.	Halt — Front, Dress. Steady.

2. *Forming Open, Close, or Quarter distance Column in front of No.* 1 *Company.*

OPEN, (CLOSE, OR QUARTER DISTANCE) COLUMN IN FRONT OF NO. 1. REMAINING COMPANIES, FOURS—RIGHT. QUICK MARCH.	Halt — Front, Dress. Steady.

3. *Forming Open, Close, or Quarter distance Column in Front, or Rear, on the Left Company.*

A Battalion in line will be formed in column on the Left company in the same manner as it is so formed on the Right company, the remaining companies forming Fours to the left.

4. *Forming Open, Close, or Quarter distance column on a Central company.*

OPEN (CLOSE, OR QUARTER DISTANCE) COLUMN, RIGHT (OR LEFT) IN FRONT, ON NO. —— FOURS-INWARDS. QUICK MARCH.	Halt, Front, Dress. *Senior Major.* Steady.

5. *Forming Open, Close, or Quarter distance Column, facing to the Rear.*

In the same manner, Column may be formed facing to the rear, from Line, upon any Company; that Company upon the caution countermarching by Files, and the remaining companies forming fours outwards, countermarching to the right, or left, and forming as already described. The company of formation will be faced, and countermarched, so as to lead to its new pivot, by command of its Captain.

OPEN, (CLOSE OR QUARTER DISTANCE) COLUMN ON NO. —— COMPANY, RIGHT (OR LEFT) IN FRONT, FACING TO THE REAR.	*The Companies, which move to the rear of the Line, will countermarch round the rear rank.*

FORMATION OF LINE FROM COLUMN.

S. 33. *Forming Line to the Front, from open column, on any named Company.*

1. *Forming Line on the Leading Company, from the Halt. Right in front.*

FORM LINE ON THE LEADING COMPANY, REMAINING COMPANIES FOUR PACES ON THE RIGHT BACKWARDS WHEEL. QUICK MARCH.	No. 1 by the Right, Dress. Eyes, front. No. —— Halt, Dress. Eyes, front.

FORM LINE. QUICK MARCH. *When the movement is completed.**	*In succession,* No. ——, Right wheel. Halt. Dress up. Eyes, front. *Senior Major.** Steady.

When the Column is Left in front, Line will be formed in the same manner as when Right in front.

2. *Forming Line on the leading Company in a direction oblique to the Front of the Column.*

In this movement the leading company will be wheeled back on its reverse flank into the direction required, the remaining companies will be wheeled back half the number of paces wheeled by the leading company in addition to the four paces described in the preceding number of this section; thus, if the leading company wheels back two paces, the remaining companies will wheel back five; the formation will be completed as already explained. If the leading company is wheeled up on the reverse flank, the line will be formed as described in Section 35 of this PART.

3. *Forming Line on the Rear Company from the Halt.*

Line may also be formed on the rear company of a column, the remaining companies first being faced to the right about, and then wheeled four paces on their right backwards, if right is in front, and on their left backwards, if left is in front, the captains remaining on the pivot flank. The movement will be performed in all respects as described in No. 1. of this Section, except that each company will move rear rank in front, and after it has wheeled into the alignment, it will receive the word "Forward" from its captain, move well to the rear, and then be halted, fronted, and dressed up into line.

4. *Forming Line on a central Company.*

FORM LINE ON NO. *——; COMPANIES IN FRONT, RIGHT ABOUT FACE. FOUR PACES ON THE RIGHT (OR LEFT) BACKWARDS WHEEL.† QUICK MARCH.	No. ——* by the right—Dress. Eyes—front. No. ——.† Halt—Dress. Eyes—front.

FORM LINE. QUICK MARCH *Front Companies.**	* Left (or right) wheel, Forward, Halt. Front—Dress up.
Rear Companies.†	† Left (or right) wheel. Halt—Dress up. Eyes—front.

5. *An Open Column on the March to the Front, or Rear, forming Line on the leading Company.*

If marching to the front, on the caution, FORM LINE ON THE LEADING COMPANY, the rear battalion aide will move out to be ready to give a distant point. The commanding officer will then give the words, REMAINING COMPANIES LEFT (or RIGHT) WHEEL, on which the leading company will continue to move straight to the front, and the remaining companies will wheel on moveable pivots, their captains changing flank by the rear. When they have completed the eighth of a circle, the commanding officer will give the word FORWARD, on which they will move on in echellon, and the captain of the leading company will give the word "Halt," change his flank, and then give the word "Dress." The movement will then be completed in the same manner as it is performed from the halt.

If marching to the rear, the first part of the manœuvre will be performed in the same manner as when the column is advancing, except that the captains will not change their flanks on the caution, and the captain of the leading company will give the word "Halt—Front Dress." The remaining companies will then form in the same manner as on a rear company from the halt.

S. 34. *An Open Column forming Line in inverted order.*

A battalion in column should be practised in forming line on the front, or rear company in inverted order, the right company on the left, and the left company on the right. The command will be given thus, IN INVERTED ORDER FORM LINE ON No. 1 COMPANY, REMAINING COMPANIES, &c.

A battalion should, if required, be able to form on the leading company, part of the remaining companies on its right, part on its left.

S. 35. *A Battalion in open Column, forming Line to the Reverse flank.*

FORM LINE TO THE REVERSE FLANK.	*Leading Company.* No. —— Right (or left) wheel. Forward. Halt—Dress up. *2nd Company.* Right (or left) wheel. Halt—Dress up. Remaining companies in succession will form in like manner on the outward flank of the last-halted company. *Major.* Steady.

Columns of Sub-divisions, or Sections, will be formed to the reverse flank in like manner.

S. 36. *Forming Line to the Front from Double Column.*

Double columns should always form line to the front on the march; the movement should therefore be commenced at sufficient distance in rear of an alignment, to allow of the two centre companies, sub-divisions, or sections continuing their advance, while the remainder are wheeling forward into echellon.

When a double column is required to form line, from the halt, without advancing the two front companies, sub-divisions, or sections, it should first be closed to quarter distance, and then be deployed, as described in Section 42 of this PART.

Line will be formed to the front on the march, from double column, on the same principles as from a single column. The following description of the formation from double column of sub-divisions will apply equally to the formation from double column of companies, or sections.

FORM LINE ON THE TWO CENTRE SUB-DIVISIONS, REMAINING SUB-DIVISIONS OUTWARDS WHEEL.—FORWARD.	Two centre sub-divisions—Halt. Four paces outwards—Close—Quick march. No. —— Right, Dress. No. —— Left, Dress. *The remaining sub-divisions will form in succession, as described in Section* 33, PART III. Right (or left) sub-division, Left (or right) wheel—Halt—Dress up. Eyes front. *Senior Major*—Steady.

S. 37. *A Battalion in Double Column, forming Line to the Right, or Left.*

1. *Forming to the Right on the March.*

COLUMN BY THE RIGHT. FORM LINE TO THE RIGHT. RIGHT WING — RIGHT WHEEL.	Halt—Dress. Eyes front. *The companies, &c., of the Left wing will form successively to their reverse flank, in the manner described in Section* 35, PART III.

Line will be formed to the Left on precisely the same principles.

2. *Forming from the Halt.*

This movement may be performed from the halt, in which case the words will be FORM LINE TO THE RIGHT (or LEFT), RIGHT (or LEFT) WING, RIGHT (or LEFT) WHEEL INTO LINE. THE WHOLE, QUICK MARCH, &c., on which the companies, sub-divisions, or sections of the named wing will wheel into line, as directed in PART II., Section 5, or 11. The other wing will step off, and the rest of the evolution will be performed as already described.

DEPLOYMENTS.

S. 38. *A Battalion in Close, or Quarter-distance Column, deploying into Line on the leading Company.*

Deployments will invariably be made on a front base, and by the flank march of Fours, unless the ground should render it necessary to move in files.

1. *From Column, Right in front.*

DEPLOY ON THE LEADING COMPANY. REMAINING COMPANIES, FOURS LEFT. QUICK MARCH.	No. 1. Right—Dress. Eyes front.
	No. 2, Front turn. Halt. Dress up. Eyes front.
	Each of the remaining Companies, in succession. Front turn. Halt. Dress up. Eyes front.
	Senior Major—Steady.

2. *From Column, Left in front.*

A Column, left in front, will deploy on the leading Company, in precisely the same manner, as a column, right in front.

S. 39. *A Battalion, in Close, or Quarter-distance Column, deploying on the Rear Company.*

1. *From Column, Right in front.*

DEPLOY ON THE REAR COMPANY. REMAINING COMPANIES, FOURS RIGHT. QUICK MARCH.	No. 5. Halt—Front—Dress.
	No. 6. By the left, Double march.
	No. 6. Halt—Dress up. Eyes front.
	No. 4. Halt—Front—Dress.
	No. 5. By the left. Quick march.
	No. 5. Halt—Dress up.
	&c. &c. &c.
	Thus each company in succession will be halted, and fronted, and then brought up into line, as soon as its front is clear.

2. *From Column, Left in front.*

A Battalion in Column, left in front, will deploy on its rear Company on the same principles, as a Battalion in column, right in front; the Companies, except No. 1, forming fours to the left.

S. 40. *A Battalion in Close, or Quarter-distance Column, right, or left, in front, deploying on a Central company.*

When a battalion is required to deploy on a central company, the companies (4. 5. 6.) in rear of the named one will move on the principles already described for a deployment on a front company, and those in front of the named company (1. 2.) and the company itself (3.) on the principles described for a deployment on a rear company.

DEPLOY ON NO. —— COMPANY, REMAINING COMPANIES FOURS OUTWARDS.

S. 41. *A Battalion in Close, or Quarter-distance Column, deploying in Inverted Order.*

A battalion in column should be practised in deploying on the leading company in inverted order, in which case the command will be IN INVERTED ORDER—DEPLOY ON THE LEADING COMPANY. A column may also, if required, deploy on the leading company, any named number of companies moving out and forming on its right, the remainder on its left. The command will then be given thus: DEPLOY ON No. 1, No. 2, 3, AND 4 COMPANIES FORMING ON THE RIGHT, REMAINDER ON THE LEFT.

S. 42. *A Battalion in Double Column deploying.*

1. *Deploying from Double column.*

A double column at Close, or Quarter distance may deploy on the two centre Companies, or Sub-divisions, in the same manner as a single column.

2. *A Double column deploying to one flank.*

If a battalion in double column should move up to the extremity of the ground on which it is to deploy, it may deploy both wings in the same direction. Thus, if a double column of sub-divisions moves up to the right extremity of the alignment which it is to occupy, it will deploy on the right sub-division of No. 1 company. The right wing will deploy on its rear sub-division (the right sub-division of No. 1 company) in the usual manner, the left wing, at the same time, taking ground to the left in fours, and when the right wing has completed its deployment, the left will continue the formation of the line by deploying on its leading sub-division.

S. 43. *A Battalion in Line changing Front, by the intermediate formation of Open column, on any named Company.*

1. *To the Right, Left thrown forward, on the right Company.*

Change of front at right angles to the old Line.

CHANGE FRONT TO THE RIGHT ON No. 1 COMPANY BY THE FORMATION OF OPEN COLUMN.	*Or* * No. 1—on the Right—backwards wheel. Quick march. Halt—Dress. Eyes front.
No. 1 COMPANY STAND FAST.*	
OPEN COLUMN IN FRONT OF No. 1. REMAINING COMPANIES, FOURS RIGHT. QUICK MARCH, &c., &c., &c.	*Remaining Companies form open Column, Left in front, on the right Company.*
RIGHT WHEEL INTO LINE. QUICK MARCH, &c., &c.	*The column will be wheeled into Line to the right.*

2. *To the Left, Right thrown forward, on the left Company.*

A line will change front to the left on the left company in the same manner as to the right on the right company, the captain of the left company changing his flank on the caution, and his company being wheeled back on its left, if the new line is to be formed obliquely to the old one. The column will then be formed on it right in front, and it will be wheeled to the left into line.

3. *To the left, Left thrown back on the right Company.*

CHANGE FRONT TO THE LEFT ON NO. 1 COMPANY, BY THE FORMATION OF OPEN COLUMN.	*If the change is to be at right angles to the old Line, the right Company will stand fast; but, if oblique to it, that Company will wheel back on its left so many paces, as will make it perpendicular to the new alignment.* No. 1 —— paces on the left—backwards wheel. Quick march. Halt—Dress. Eyes front.
OPEN COLUMN IN REAR OF NO. 1 COMPANY. REMAINING COMPANIES, FOURS RIGHT. QUICK MARCH, &c., &c., &c.	*The remaining Companies will then form open Column, right in front, on the right Company.*
LEFT WHEEL INTO LINE. QUICK MARCH, &c., &c.	

4. *To the right, Right thrown back, on the left Company.*

A line may change front to the right on the left company, in the same manner as to the left on the right company. In this case the captain of the left company will not have to change his flank; if the new line is to be formed obliquely to the old one, his company will be wheeled back on the right, the column will be formed left in front in rear of it, and then wheeled to the right into line.

5. *To the Right, or Left, on a central Company.*

CHANGE FRONT TO THE RIGHT (OR LEFT) ON NO. —— COMPANY, BY THE FORMATION OF OPEN COLUMN.	No. ——, —— paces on the right (or left) backwards wheel. Quick march. Halt—Dress. Eyes front.
OPEN COLUMN LEFT (OR RIGHT) IN FRONT, ON NO. ——, &c. RIGHT (OR LEFT) WHEEL INTO LINE. QUICK MARCH, &c., &c.	

6. If necessary, in order to save time, the Company of formation may be wheeled into Line as soon as the alignment has been taken up; the remaining companies, if moving to the front of the old alignment, will receive the word "Front form Company" from their captains, as they reach their covering serjeants. If moving to the rear of the old alignment, they will move round their coverers, march straight on the flank of the company next to them already in line, and then be halted, fronted, and dressed in succession by their captains.

FORMATION OF SQUARES.

GENERAL PRINCIPLES.

I.

Use of Squares.—Men are formed into square to resist attacks of cavalry; care should always be taken not to expose men unnecessarily in this formation to the fire of artillery.

II.

The Four-deep Square.—The formation of a square four deep is the most eligible for a battalion; it is sufficiently strong to resist cavalry, and gives space for the officers, serjeants, band, &c. in the centre, and enables every man to fire.

III.

The Two-deep Square.—A battalion may be formed into square two deep to protect baggage or treasure against infantry only.

IV.

Solid Square.—Any compact mass of soldiers will be safe against cavalry, if the outside men kneel down and slant their bayonets outwards.

S. 44. A Battalion in Column, forming Square.

1. *Forming Square on the leading Company of an Open column.*

ON THE LEADING COMPANY FORM SQUARE. QUICK (OR DOUBLE) MARCH.	*Remaining Companies, except the two in rear of the Column.* No. —— Sections—outwards. *Two rear Companies close up.* No. —— Halt. Right about face.

2. *Forming Square on the rear Company of an Open column.*

Eight Companies, right in front.

ON THE REAR COMPANY, FORM SQUARE. RIGHT ABOUT FACE. QUICK (OR DOUBLE) MARCH.	*No. 8 Company will stand fast.* *No. 7 will close upon No. 8, and halt.* *No. 6 will close upon No. 7, and receive,* Front turn. Sections outwards. *Each Company (except Nos. 1 and 2) in succession will close on the last halted Company, and receive,* No. —— Front—turn. Sections outwards. *As No. 3 Company receives the word,* Front turn. Sections outwards—— *Nos. 1 and 2 Companies will run into the Square, and receive,* No. 2—Halt—Front. No. 1—Halt—Front.

If a Column on the march is ordered to form Square, the leading Company will at once receive the words "No. —— Halt—Dress" from its Captain.

3. *Forming Square on the centre, from Open column.*

Right in front.

ON THE LEFT (OR RIGHT) CENTRE COMPANY, FORM SQUARE. RIGHT (OR LEFT) WING, RIGHT ABOUT FACE. QUICK (OR DOUBLE) MARCH.	Sections—outwards. Front turn. Sections—outwards. Sections—outwards. &c. &c. &c. *The Square will be completed on the Company of formation, as described in Nos.* 1 *and* 2 *of this Section.*

4. *A Column taking ground to a flank by Fours, forming Square.*

When a battalion in open column taking ground to a flank by fours, is required to form square, the commanding officer will give the words ON THE LEFT (or RIGHT) CENTRE COMPANY FORM SQUARE, WINGS INWARDS TURN, on which the wings will turn inwards, the captain of the named company will give the words "Sections outwards," and square will be formed as already described. When the column is right in front the square will form on the left centre company: when left in front, on the right centre company.

5. *A Battalion in Quarter-distance Column, forming Square.*

A column at quarter distance will be formed into square in the same manner as an open column, except that the commanding officer will give the word SECTIONS OUTWARDS to all the centre companies, as the second company closes on the first.

A quarter-distance column taking ground to a flank by fours, should not be ordered to form square on the centre; it should be ordered to turn to the front and then form on the leading company. A quarter-distance column retiring should also be ordered to turn to the front before forming square.

S. 45. *A Battalion in Double Column, forming Square.*

A double column of sub-divisions will form square on the two leading sub-divisions, in the same manner as a single column of companies forms square on the leading company. A double column of companies, when it consists of ten or more companies, may form square in a similar manner, the side faces being wheeled outwards by sub-divisions instead of sections; but when it consists of less than ten companies, say six, square will be formed as follows:—The whole will form four deep and close to the centre, the two leading companies will stand fast, or halt, if on the march, forming the front face; the two next will move on, and when at sub-division distance from the front, will wheel outwards by companies forming the side faces; the two rear companies will close on the flanks of the two side faces, halt, face to the right about, and thus complete the square.

S. 46. *A Square preparing to resist Cavalry.*

PREPARE FOR CAVALRY. READY. FILE FIRING FROM THE RIGHT (OR LEFT, OR FROM BOTH FLANKS) OF THE FRONT (OR RIGHT, OR LEFT) FACES. COMMENCE FIRING. KNEELING RANKS —READY, PRESENT. LOAD.

S. 47. *A Battalion in Square, re-forming Column, or Double column.*

1. Re-forming Column, or Double column of Sub-divisions.

RE-FORM COLUMN. QUICK MARCH.	*The Sections of the side faces will wheel backwards, and re-form Companies*——
	No. —— Halt—Dress.
	The front Company will advance——
	No. —— Halt—Dress.
	The two rear Companies will retire.
	No. —— Halt—Front—Dress.

A Double column of Sub-divisions will be re-formed in like manner.

2. Re-forming Double Column of Companies.

A square formed from double column of companies, as described in Section 45 of this PART, will be reduced, when it consists of ten or more companies, and has been formed according to the first method, in a similar manner to that described in No. 1 of this Section, the side faces wheeling back by sub-divisions instead of sections, and the two front and four rear companies moving out to sub-division distance; but when it consists of less than ten companies, and has been formed according to the second method, the two front companies will stand fast, the flank men (on the caution) facing to their front, the side faces will (on the words QUICK MARCH) wheel back by companies into column, and the two rear companies will move back, and halt and front at sub-division distance; the whole will then be formed into two deep.

S. 48. *A Battalion in Line forming Square on any named Company, and re-forming Column, or Line.*

1. *Square in rear of the Left centre Company.*

ON THE LEFT CENTRE COMPANY, FORM SQUARE. FOURS INWARDS.* QUICK MARCH.	* *All except the left centre Company.*		
	No. 3.	Halt—Front.	
	No. 5.	Front turn.	Sections outwards.
	No. 2.	Front turn.	Sections outwards.
	No. 6.	Halt—front.	Right about face.
	No. 1.	Halt—front.	Right about face.

This square may be formed in rear of any company, but the formation in rear of the left centre company is the most convenient; when companies meet, the general rule will be that they pass each other left arm to left arm.

2. *Forming Column, and Re-forming Line.*

The above square will be formed into column, as described in the preceding section. If it is to remain in column, it will be numbered off afresh from the front, but if it is to be re-formed at once into line, it will be deployed, the companies forming fours outwards, and moving out to their original positions.

Should it be necessary to form line on the original alignment, before forming column, the leading company must be ordered to stand fast, instead of opening out to quarter distance, the remainder of the column will then be formed as usual, and will be deployed into line on the leading company as above directed.

3. *Forming Quarter Distance, or Open Column, and then Square.*

If it is not necessary to open fire immediately, the simplest method will be to form quarter-distance column in the usual manner, on any named company, and then form square on the leading company; a line may also be wheeled into open column, and square then formed on the leading, or the centre company; these squares will be reduced as described in the preceding section.

S. 49. A Battalion in Line, or Echellon, forming Company squares, and re-forming Line, or Echellon.

1. *Forming Company Squares.*

FORM COMPANY SQUARES.	No. ——. Form close column of sections. Quick march. Prepare for cavalry. Ready, &c. —Re-form Column.

2. *Re-forming Line, or Echellon.*

RE-FORM LINE (OR ECHELLON) QUICK MARCH.	*No. 1, 3, and 4 sections face outwards, on the words*—RE-FORM LINE (OR ECHELLON).

If there is time, after the companies are formed from line into close columns of sections, they may be wheeled the eighth of a circle to the right, so as to place them in echellon. The commanding officer will give the word WHEEL INTO ECHELLON; the captains will then wheel their companies by their own words of command, "Right Wheel, Quick March, Halt—Dress." Before the columns are again formed into line, they must be wheeled back into their former positions.

S. 50. A Close column forming Square, and the square being re-formed into Column.

1. *Forming the Square.*

FORM SQUARE. FOURS OUTWARDS.*	* *The two front and two rear Companies stand fast; the remainder form Fours outwards by subdivisions.*
QUICK MARCH.†	† *The fours will close up; No. 2 company, if right is in front, will step back a pace and a half; No. 1 three paces; the second company from the rear will face to the right about; and the rear company will close up a pace and a half, and face to the right about.*

2. *Re-forming Column.*

RE-FORM COLUMN. QUICK MARCH.	*On the word,* RE-FORM COLUMN, *the fours will step back to their proper distance, and upon the words,* QUICK MARCH, *they will front and form two deep; No.* 1 *will advance three paces; No.* 2 *a pace and a half; the rear company will retire a pace and a half, and come to the front together with the second company from the rear by command from their Captain.*

S. 51. *A Square marching in any direction.*

THE SQUARE WILL ADVANCE (RETIRE, OR MOVE TO THE RIGHT, OR LEFT). INWARDS, FACE.* QUICK MARCH. HALT—FRONT.	* *The Face, that is to lead, stands fast; and those, on either side of it, face to the right, and left; the Face, in the rear of it, faces to the right about.*

S. 52. *Battalion in Line forming Square Two deep, and re-forming Line.*

1. *Forming Square.*

ON THE TWO CENTRE COMPANIES, TWO DEEP, FORM SQUARE.* QUICK MARCH.†	* *Centre companies stand fast.* *Flank companies face inwards.*‡ *Remainder face to the right about.*§ † *The centre companies close inwards four paces each, to fill up the interval left by the colours.* § *Right wing companies.* Forward. Right wheel. Halt—front, Dress. *Right face of square.* *Left wing companies.* Forward. Left wheel. Halt—front, Dress. *Left face of square.* ‡ *Move inwards.* Halt. Rear face. *Rear face of square.*
THE SQUARE WILL ADVANCE (RETIRE OR MOVE TO THE RIGHT, OR LEFT).—AND FACES FOURS INWARDS. FACE, RIGHT ABOUT FACE. QUICK MARCH. HALT—FRONT.	*The faces that are to move to a flank form fours to the right, and left. The face to be in rear will be faced to the right about.*

2. *Re-forming Line.*

RE-FORM LINE. QUICK MARCH.	*The flank Companies face outwards. Companies forming the side Faces will wheel to the right, and left; and, when in echellon, receive the word* "Forward." *The flank companies move across in Fours to the outward flanks of the companies, which stand next to them when in Line, they then change their direction parallel to the alignment, and, when clear of the other companies, are halted and dressed up into Line.* No. —— Forward. No. —— Right, (or left) wheel. Halt—Dress up. No. —— Halt—front. Dress up.

MOVEMENTS, AND CHANGES OF FRONT IN ECHELLON.

S. 53. *A Battalion wheeling forward by Companies from Line into Echellon.*

1. *Wheeling into Echellon from the Halt.*

WHEEL INTO ECHELLON OF COMPANIES, TO THE RIGHT (OR LEFT). COMPANIES —— PACES TO THE RIGHT (OR LEFT) WHEEL. QUICK MARCH. THE ECHELLON WILL ADVANCE. QUICK MARCH.	Halt—Dress. Eyes front.

2. *Wheeling into Echellon on moveable pivots.*

TAKE GROUND TO THE RIGHT (OR LEFT) IN ECHELLON OF COMPANIES (SUB-DIVISIONS, OR SECTIONS). ON THE MOVE BY COMPANIES (SUB-DIVISIONS, OR SECTIONS) RIGHT (OR LEFT) WHEEL. QUICK MARCH. FORWARD.

If a Battalion is required to wheel into echellon to the rear, it will be faced about, and the companies, sub-divisions, or sections, will be wheeled forward, rear rank in front.

3. *Wheeling into Echellon on the March.*

TAKE GROUND TO THE RIGHT (OR LEFT) IN ECHELLON OF COMPANIES (SUB-DIVISIONS, OR SECTIONS).

BY COMPANIES (SUB-DIVISIONS, OR SECTIONS) RIGHT (OR LEFT) WHEEL, FORWARD.

S. 54. *A Battalion in Echellon of Companies, wheeling back into Line parallel to that from which it has formed.*

WHEEL BACK INTO LINE. QUICK MARCH.	Halt. Dress. Eyes front.

This movement may also be performed on the march, the Captains marking time, and their Companies wheeling back on them into Line: the commanding officer will give the word FORWARD, when the wheels are completed.

S. 55. *A Battalion in Echellon, halted, forming Line in a direction oblique to that from which it was wheeled into Echellon.*

FORM LINE ON THE LEADING COMPANY, WHICH WILL WHEEL, &c., &c. REMAINING COMPANIES —— PACES TO THE RIGHT, (OR LEFT) (OR ON THE RIGHT, OR LEFT BACKWARDS) WHEEL. QUICK MARCH. FORM LINE. QUICK MARCH.	*Each company in succession.* No. —— Right (or left) wheel. Halt, Dress up. Eyes front.

S. 56. A Battalion in Line changing Front on a Flank Company, by throwing forward the rest of the Battalion.

CHANGE FRONT ON THE RIGHT (OR LEFT) COMPANY. LEFT (OR RIGHT) THROWN FORWARD. REMAINING COMPANIES —— PACES TO THE RIGHT (OR LEFT) WHEEL. QUICK MARCH, &c., &c.	No. —— To the Right (or left) wheel; Or—No. ——, —— paces to the Right (or left) wheel. Quick march. Halt, Dress. Eyes front.
FORM LINE—QUICK MARCH, &c., &c.	

S. 57. A Battalion in Line changing Front to a flank, by throwing backwards the rest of the Battalion.

CHANGE FRONT ON THE LEFT (OR RIGHT) COMPANY, RIGHT (OR LEFT) THROWN BACK.	No. —— On the Right (or left) backwards wheel; (or No. ——, —— paces on the Right (or left) backwards wheel.) Quick march. Halt, Dress. Eyes front.
REMAINING COMPANIES —— PACES, RIGHT ABOUT FACE. RIGHT (OR LEFT) WHEEL. QUICK MARCH.*	*No. —— Halt. Front, Dress. Eyes front. No. —— Halt, Dress. Eyes front.
FORM LINE. QUICK MARCH.	No. —— Right (or left) wheel, Forward. Halt, Front. Dress up. Eyes front.

S. 58. A Battalion in Line changing Front on a centre Company, or on the two centre Companies, by advancing one Wing, and retiring the other.

CHANGE FRONT ON THE CENTRE (OR ON NO. —— COMPANY) RIGHT (OR LEFT) THROWN FORWARD.	*If on the two centre Companies.* Two centre Companies on the centre, Right (or left) wheel; Or —— paces, Right (or left) wheel. Quick march. Halt, Dress. Eyes front. *If the change of front is to be on the centre of a Company.* No. —— on the centre, Right (or left) wheel; Or —— paces, Right (or left) wheel. Quick march. Halt, Dress. Eyes front.
LEFT (OR RIGHT) WING, RIGHT ABOUT FACE; OR, COMPANIES ON THE LEFT (OR RIGHT) RIGHT ABOUT FACE. COMPANIES —— PACES RIGHT (OR LEFT) WHEEL. QUICK MARCH. FORM LINE. QUICK MARCH; &c., &c.	

A Battalion on the march may be ordered to change front on a flank Company in echellon, without halting, the Company wheeling on moveable pivots; in this case the flank Company of formation will wheel at the double.

S. 59. *A Battalion in Line advancing, or retiring in direct Echellon of Companies from either Flank.*

THE BATTALION WILL ADVANCE,* (OR RETIRE †) IN DIRECT ECHELLON OF COMPANIES, AT WHEELING (OR —— PACES) DISTANCE, FROM THE RIGHT (OR LEFT).	*In succession.* * No. —— By the Right (or left) Quick march. † Or, No. —— Right about face. By the Right (or left) Quick march.

S. 60. *Re-forming Line from Direct Echellon.*

1. *Forming Line on the leading Company.*

RE-FORM LINE ON THE LEADING COMPANY. REMAINING COMPANIES, QUICK MARCH.	

2. *Forming Line, on the Rear Company.*

RE-FORM LINE ON THE REAR COMPANY. REMAINING COMPANIES, RIGHT ABOUT FACE. QUICK MARCH.	Halt, Front, Dress up. Eyes front.

3. *Forming Line, on a Central Company.*

RE-FORM LINE ON NO. —— COMPANY. COMPANIES IN FRONT, RIGHT ABOUT FACE. FORM LINE. QUICK MARCH.	*Front Companies.* Halt, Front, Dress. Eyes front. *Rear Companies.* Halt. Dress. Eyes front.

4. *Forming Line on the March.*

A Battalion, in direct echellon on the march, may form Line in like manner: if to the Front, the leading Company will be halted, on the caution; if on the Rear, or a Central Company, the named Company will be halted, on the words "REMAINING COMPANIES, (OR COMPANIES IN FRONT) RIGHT ABOUT TURN."

5. *Forming Line, at right angles to the original Alignment.*

FORM LINE TO THE RIGHT. BY COMPANIES, RIGHT WHEEL, FORWARD; &c., &c.	

When the Advance has been made from the Right, Line may be formed to the Left, in like manner.

S. 61. *A Battalion in direct Echellon, forming Line in an oblique direction.*

FORM OBLIQUE ECHELLON ON THE LEADING COMPANY. REMAINING COMPANIES, RIGHT (OR LEFT) HALF FACE, QUICK MARCH. WHEEL BACK INTO LINE. QUICK MARCH, &c.	Halt, Front, Dress.

A Direct echellon may be wheeled forward into Column, and then formed into Square, either on the centre, or on the leading Company at any moment; or the Companies of a direct echellon may be formed into Company Squares.

STREET FIRING.

S. 62. A column at open, half, or quarter distance, formed in a street or in narrow ground where deployment is impracticable, may be required to fire either when advancing, or retiring. It will be performed in the following manner:—

1. *Street firing, advancing.*—Three companies will be ordered to advance from the column, leaving sufficient room between them and the remainder of the column for a gun, or body of cavalry to form. The second and third companies will close on the first. When required to fire, the two front companies will kneel down, and the third will fire over their heads; the second will then receive the word "Ready," on which it will spring up, and on the word "Present" will deliver its fire; lastly, the front company will fire kneeling, each company loading as soon as it has fired. The leading company may then be ordered to rise and charge, or the first and second companies may be ordered to open out to half distance from the rear, and the whole then wheeled back by sub-divisions to each side of the street to allow the gun to fire between them, or the cavalry to charge; it may occasionally be of use to extend files along each side of the streets to fire up into the windows.

2. *Street firing, and retiring.*—In retiring, the leading division will give its fire, slope arms, face outwards by sub-divisions, file to the rear, re-form company, load, and remain halted, until its front is again clear, or the whole column is put in motion. The moment the front of the second company is clear it will give its fire, face outwards by sub-divisions, and file to the rear as above directed; and so on by companies in succession; the companies thus follow each other in succession: when the front of the column occupies the whole breadth of the street, the outward files of companies will double in the rear, to give the companies, which have fired, room to pass.

It must never be forgotten, in entering towns or villages occupied by the enemy, that the first thing to be done, on gaining a footing in the place, is to clear the houses on both flanks, and the column should on no account proceed through the streets without previously occupying the houses on either hand: the troops employed for that purpose breaking through partition walls, or pushing on from house to house, so as to accompany the march of the main body and protect its flanks.

INSTRUCTIONS FOR PITCHING, AND STRIKING TENTS.

1. Whenever possible, the quartermaster, or an officer acting for him, with a non-commissioned officer and a camp colourman per company, will precede the corps to be encamped.

2. This officer will take up ground for the companies' and the officers' and other tents, &c., according to the directions he may have received, to conform to one or other of the methods laid down in the "Regulations for Encampments," marking by a picket the spot to be occupied by each tent-pole, and taking care that the lines of tents are perpendicular, and correctly covered.

3. Before arriving in camp the men will be told off for their several functions as pole-men, peg-men, and unpackers of tents, two men being allotted for each of these duties, and six in all for every tent. More than this number only impede each other.

Each tent requires, therefore, one section of threes to pitch, or strike it.

4. From the remainder of the company, the parties will be told off for provisions, wood, water, fire, guards and pickets, and for the pitching of the officers' orderly-room, store-room, guard-tents, &c.

To each tent, as far as possible, a non-commissioned officer will be told off.

5. It is known that the soldiers' tent, with its cords, occupies a space of nearly 6 yards—that is, between 7 and 8 paces from pole to pole.

6. The pole-men, being stationed at the spots indicated by the pickets, the pole is lowered, and the cap of the tent fixed on, and all things prepared for the raising of the tent. On the signal, or word of command, the whole of the poles are raised together, the skirt of the tent being lifted over the pole-man's head.

7. It will be remembered, that, to insure stability, four of the cords which divide the circumference accurately into quarters, must be first made fast before any of the others.

8. Each cord must be stretched on the true prolongation of the tent seam.

9. The slides must be made fast at an equal distance from the tent and the ground peg, so as to permit shifting, as expansion or contraction of the cord ensues on atmospheric changes.

10. The non-commissioned officer sees that the door is properly placed, and attends especially to the fastenings of the first four pegs, with a view to the general uprightness of the pole and security of the tent, under the general superintendence of the company's officers; one being stationed at the flank, the more easily to detect and correct errors.

11. In order to strike the tents, all the pegs are drawn except the four first driven, and four men place themselves at these in readiness for the signal; they draw these pegs, and hold down the tent till the signal be given.

12. On the signal, the pole-men lower the poles to the rear, and come out by the door, bringing the poles with them.

13. In rolling up the tent, the cap is turned on one side, in such a manner as shall make it visible at one end when the tent is rolled. This prevents the cap from cutting the tent.

PART II.

CAVALRY SWORD EXERCISE.

SECTION I.—EXTENSION MOTIONS.

Vide " Infantry Sword exercise," *page* 10.

SECTION II.—CUTS. GUARDS. POINTS.

Words of Command.

Right engage.
Assault.
One
Two
Three } Right.
Four
One
Two
Three } Left.
Four
Slope swords.

Right defend.
Second.
Third.
Fourth.

Left defend.
Second.
Third.
Fourth.
Slope swords.

GUARDS, AND POINTS.

Words of command.

Guards, and Points.	
Right—Defend.	Point.
Second.	Point.
Third.	Point.
Fourth.	Point.
Left—Defend.	Point.
Second.	Point.
Third.	Point.
Fourth.	Point.
Slope swords.	

SWORD EXERCISE.

Words of command.

Sword exercise.
Right engage.
Assault.
One —Point.
Two —Point.
Three—Point.
Four —Point.
Slope swords.

Left engage.
Assault.
One —Point.
Two —Point.
Three—Point.
Four —Point.

PURSUING PRACTICE.

Words of command.

Pursuing practice.	
Assault.	
One —Point.	Right.
One —Point.	Left.
Three—Point.	Right.
Three—Point.	Left.
Slope swords.	

The men being complete in the Sword exercise by word of command will go regularly through the exercise in the same manner as it will be shown at Reviews, Inspections, &c., taking the time of each motion, according as Right or Left is attached to the words of command.

Words of command.

Right Prove distance.
Slope swords.
Front Prove distance.
Slope swords.
Sword exercise.
Pursuing practice.

SECTION VI. OFFICERS' SALUTE.

Words of command.

Attention. Rear rank take Order. March. Present arms. Advance arms. Rear rank take close order. March.

CARBINE EXERCISE.

CARBINE EXERCISE ON FOOT.

MANUAL EXERCISE.

Words of command.

Attention. Present arms—Two—Three. Advance arms—Two. Port arms. Advance arms—Two. Support arms. Stand at ease.

PLATOON EXERCISE.

Words of command.

Spring arms—Two. Load. Handle cartridge—Two. Draw ramrod. Ram down cartridge—Two. Return ramrod. Prime—Two. Ready. Present. Fire. Advance arms. Trail arms. Advance arms. Unspring arms—Two. Support arms. Stand at ease.

CARBINE EXERCISE ON HORSEBACK.

Words of command.

Spring arms—Two. Load. Handle cartridge—Two. Draw ramrod. Ram down cartridge—Two. Return ramrod. Prime—Two. Ready. Front present. Fire. Load. Ready. Left present. Fire. Advance arms. Carry arms. Sling arms—(is taken from any of the preceding positions). Strap arms—(from being slung, the carbine may be strapped).

CARBINE EXERCISE ON FOOT; FOR LOADING, AND FIRING SHARP'S BREECH-LOADING CARBINE.

Words of command.

Prepare to load—Two—Three—Four. Load—Two. Cap—Two—Three.*

At —— yards. Ready. Present—Two—Three—Four—Five. Load.

CARBINE EXERCISE ON HORSEBACK, FOR SHARP'S BREECH-LOADING CARBINE, carried in a bucket.

Words of command.

Spring arms—Two. Prepare to load—Two—Three—Four. Load—Two. Cap—Two—Three.* At —— yards. Ready. Front present—Two—Three—Four—Five. Load, (as before detailed). Ready. Left present. Advance arms. Carry arms. Sling arms. Strap arms.

PISTOL EXERCISE.

Words of command.

Draw pistol. 1st motion. 2nd motion. Prime, and load. Ram down cartridge. Make ready. To the front, Present. (Fire. Prime, and load; as before directed.) Make ready. To the left, Present. (Prime, and load; as before.) To the right, Present. (Fire. Prime, and load; as before.) To the rear, Present. (Fire, &c.; as before.) Return pistol. 1st motion. 2nd motion.

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* N.B. The motions to "Cap" will be unnecessary when Primers are used.

LANCE EXERCISE.

Words of command.

Round.

Right front.
Right.

Right rear.
Left rear.
Left.

Left front.

Engage.
Wave.
First point.
Second point.
Guard.
Thrust.
Parry.
Third point.
Fourth point.
Guard.
Thrust.
Fourth point.
Carry lance.

FIRST DIVISION.

CAVALRY ATTACK, AND DEFENCE.

Words of command.

Engage.

Right front.	Wave, Second point, and Guard.
Left front.	Wave, Fourth point, and Guard.
Right rear.	Third point, and Guard.
Left rear.	Fourth point, and Guard.

Carry lance.

SECOND DIVISION.

AGAINST INFANTRY.

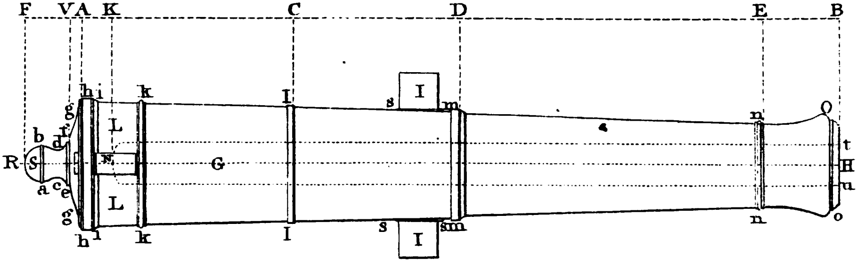
Words of command.

Engage.

Right front.	First point, and Thrust.
Left front.	Fourth point, and Thrust.
Right rear.	Third point.
Left rear.	Fourth point.

Carry lance.

A BRASS GUN.



NAMES OF THE SEVERAL PARTS OF A GUN.

AB	*Length of the Gun*	L	*Vent Field*	h	*Base Ring*
AC	*First Reinforce*	N	*Vent*	i	*Base Ring Ogee*
CD	*Second Reinforce*	O	*Swell of the Muzzle*	k	*Vent Field Astragal & Fillets*
DE	*Chase*	VAK	*Breech*	l	*First Reinforce Ring*
EB	*Muzzle*	S	*Button*	m	*Second Reinforce Ring & Ogee*
FA	*Cascable*	a b	*Button Astragal*	n	*Muzzle Astragal & Fillets*
GH	*Bore*	c d	*Neck*	o	*Muzzle Mouldings*
RH	*Axis of the Piece*	e f	*Neck Fillet*	s	*Shoulder of the Trunnion*
I	*Trunnions*	g	*Breech Ogee*	t u	*Diameter of the Bore or Calibre*

PART III.

ORDNANCE, CARRIAGES, ETC.

ORDNANCE.

GUNS.

Guns are distinguished from each other by their metal, and weight of their shot.

A Gun is divided into five parts, which are named *Cascable, First re-inforce, Second re-inforce, Chase, Muzzle.*

The metal is made thicker towards the breech than at the muzzle, to strengthen the piece, for the elastic force of the Gunpowder is there greatest, and diminishes in power as the space it occupies is extended. The metal is made thinner towards the muzzle to make the gun lighter.

The Dispart is half the difference between the diameter of the Gun at the base ring, and at the swell of the muzzle. By affixing on the muzzle a piece of metal equal to the height of the dispart, the line of sight will be made parallel to the axis of the bore, and therefore an object within point blank range can be seen. Howitzers, and some guns which have a patch or projection on the upper part of the muzzle, have no dispart, the semi-diameter of the muzzle with the patch added to it being equal to the semi-diameter of the base ring. Iron ordnance (Bloomfield's) are intended to have a degree and a half dispart, but the founder is allowed two-tenths of an inch variation in casting Iron ordnance, for any difference which there may be between the intended and actual diameter of the base ring, and muzzle.

Brass Field Guns 6, and 3-pounders, 3 cwt. (4 feet), have a dispart of one degree; 3-pounders 2¼ cwt. (3 feet) have a degree and a half; and 12-pounders, and 9-pounders have one degree and a quarter.

The Angle of dispart is the number of degrees the axis of the bore would point above the object aimed at, when laid by the surface of the gun.

Point blank range is when the piece is laid at the object without any elevation; the plane and the axis of the bore being parallel to each other. *Its distance is measured* from the muzzle of the piece (fired with the service charge of powder) to the first graze of the shot, or point at which it first touches the ground.

When a Shot is fired from a gun, it is acted upon by three forces:—

1st. The explosion of the Powder, which urges it forward.

2nd. The resistance of the Air, which tends to stop it.
3rd. The force of gravity, which causes it to descend.

When a Shot has been fired from a gun one second of time, it has fallen $16\frac{1}{12}$ feet; in two seconds, $64\frac{1}{3}$ feet; in three seconds, $144\frac{3}{4}$ feet; and proportionally for every additional second.* For this reason, it is necessary to give a certain degree of elevation to a gun: as, for instance, should *the time of flight* of a shot be two seconds, the gun must be pointed $64\frac{1}{3}$ feet above the object intended to be struck, because in that time it will have fallen through that space; therefore, the more distant the object is, the greater must be the elevation given to enable the shot to reach it.

There are three modes of extending the range of a Shot without increasing the charge of powder, viz.:—

1st. By raising the piece to a higher level.
2nd. By giving its axis greater elevation.
3rd. By excentric projectiles; recent experiments having shown that if the centre of gravity is placed directly above the centre of figure the range is greatly increased.

A Tangent scale is affixed to the breech of Guns, and Howitzers, by means of which the requisite elevation may be given, and the object seen at the same time. This scale has divisions, called degrees, marked on it, and it is placed in a groove at the breech, from which it can be raised (being fastened by a screw) to give the necessary elevation.

The divisions on the Tangent scale may be approximately found by multiplying the length of the piece in inches, from the base ring to the swell of the muzzle, by ·017455, and the product will give the length, nearly, of each degree, or division on the tangent scale. By subtracting the dispart from this product, the length of the tangent scale above the base ring for one degree of elevation will be obtained.

When there is no dispart sight, the scale can only be used for elevations above the dispart angle. In this case the divisions must be marked, considering the top of the scale as the length corresponding to the dispart angle.

Tangent scales. LAND SERVICE.

Tangent scales for brass ordnance (both for land, and sea service) are of metal, and fit into a groove bored in the breech of the gun.

There are three kinds of tangent scales for iron guns used in the land service.

1. *The metal scale,* fitted to a metal block attached to the breech of the gun. This is used with Millar's dispart sight, also with the muzzle sight, in those guns where the shape of the breech admits of the scale being made of sufficient length.

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* *Note.*—Vide "Motion," "Forces," &c., Velocity, Gravity, and Amplitude.

2. No. 1 wooden tangent scale is issued with Millar's sights, in addition to the metal scale, and is used for giving elevations beyond what can be obtained by the latter. Those now issued are made to fit the block with great accuracy. A piece of metal is also screwed on, into which the head of the metal scale is intended to fit. The latter should be raised as much as possible, and screwed tight, but not to prevent the wooden scale resting upon the top of the block.

3. No. 2 wooden tangent scale is intended for guns not fitted with Millar's sights. They can only be used for giving elevations above the dispart angle of the gun.

Tangent Scales, SEA SERVICE.

For sea service iron ordnance, all breech tangent scales are made of hexagonal metal tubing, on the sides of which the elevation, and corresponding ranges are marked. They are fitted to gun-metal blocks attached to the breech of the gun. There is also issued for broadside guns, a wooden tangent scale, which is applied to the quarter sight, and by means of which the elevation of the gun may be determined.

The Sights of a gun are two small notches marked on the upper part of the base ring (or on the top of the tangent scale) and swell of the muzzle.

The line of metal is an imaginary line drawn along the surface of the metal between the two sights.

The line of metal Elevation is obtained by laying a Gun at an object by means of the sights, without giving any elevation; from the thickness of metal at the breech, the line of metal elevation varies from one to two degrees.

The Centre of metal is indicated by a line drawn from the sight of the base ring to that of the swell of the muzzle.

Windage is the difference between the diameter of the bore, and that of the shot. The windage formerly allowed was one-twentieth the diameter of the shot, but it is now reduced considerably: (Field Guns have only one-tenth of an inch) and this diminution of windage is very beneficial, longer ranges being obtained with the same charges of powder, and also greater precision of fire.

The Vent, for every nature of Ordnance, is two-ninths of an inch in diameter.

Bouching a gun is fixing a pure copper vent into it; which is done by drilling a hole in the piece, where the vent is usually placed, about one inch in diameter, and screwing therein a piece of wrought copper, with a vent of two-ninths of an inch through the centre of it.

Tertiating a gun is examining the thickness of metal, whether the bore is perfectly straight, the trunnions properly placed, &c. It is performed by means of calliper compasses, and other instruments.

Quadrating a gun is ascertaining if it is properly placed on its carriage, and if the wheels are of an equal height.

A Gun is honeycombed when the surface of the bore has cavities, or holes in it.

The Length of a gun is ascertained by measuring it from the rear of the base ring to the face of the muzzle.

The Calibre of a gun is the diameter of the bore.

To find the Length of a gun, in feet and inches, its length in Calibres being known—

Divide the product of the number of Calibres and the diameter of the bore, in inches, by 12, and the quotient will be the length in feet and inches.

To find the Number of calibres in the Length of a gun.

Divide the length of the gun in inches by the number of inches in the calibre.

Gun metal is a compound of 8 lb. or 10 lb. of tin, to 100 lb. of copper. The property of tin being to harden, the largest proportion (10 lb.) is used for mortars, they requiring a greater degree of hardness than guns.

Ordnance cast of gun metal are generally designated *Brass Ordnance.*

Brass guns are used for field batteries, they having been considered preferable to iron for the service, being lighter than iron guns could be cast of the same calibre, without risking their bursting.

Brass guns are, however, soon rendered unserviceable by repeated and quick firing.

Iron guns are better adapted for batteries in the attack or defence of towns or fortresses, and also for service on board ship; being less expensive than brass, and better able to sustain long-continued and rapid firing. At the siege of Badajoz the firing continued for 104 hours, and the number of rounds fired from each 24-pounder averaged 1249; at the siege of St. Sebastian, each piece fired about 350 rounds in 15½ hours. None of these guns were rendered unserviceable; but three times the number of brass guns would have been required to produce the same effect, or maintain such long and rapid firing.

Service Charges of powder.

For heavy guns	⅓ the weight of the shot.
For light do.	¼ do. do.

The Point blank range of Iron 32, 24, 18, and 12-pounders with solid shot varies from 380 to 260 yards; from which to 1200 yards, every ¼ degree increases the range about 100 yards; and from 1200 to 1500 yards, every ¼ degree increases the range about 50 yards.

The Point blank range of Brass, 12, 9, and 6-pounders, with solid shot, is 300 yards, and from which to 700 yards, every ¼ degree elevation increases the range 100 yards; from 700 to 1000, every ¼ degree increases it 75 yards, and from 1000 to 1200, every ¼ degree increases it 50 yards.

The Point blank range of Brass, 12, 6, and 3-pounders is 200 yards, from which to 600 yards, each ¼ degree increases the range 100 yards, and from 600 to 1000, each ¼ degree increases it 50 yards.

Note.—For Weights, Dimensions, Ranges, Charges, &c., vide Tables.

HOWITZERS.

Howitzers are a short description of Ordnance, either Brass, or Iron, and are used for projecting Shells. Their principal advantages are that they can be more easily loaded, and are considerably lighter, in proportion to their calibre, than Guns; and they also may be used as Mortars. They have no dispart, the diameter of the base ring, and swell of the muzzle being equal, except in the 24, and 12-pounders; which, however, are provided with a patch to make up the difference.

Millar's howitzers differ from the old pattern in the increased length, being from six to ten calibres; and in the conical form given to their Chambers (called *Gomer*) which are the frustrum of a cone, terminating in an hemisphere.

Note.—Vide Tables for Weights, Dimensions, Ranges, Charges, &c.

CARRONADES.

A Carronade is a short piece of Iron Ordnance, with a loop under the reinforce instead of trunnions. Its construction is materially different to that of guns; having a chamber; a part scooped out inside the muzzle forming a cup; also a patch on the reinforce. They take their name from the Carron Foundry (where they were first cast for the Navy in 1779), are considerably lighter than Guns of similar calibres, and are fired with charges of about one-twelfth the weight of the shot.

Carronades are chiefly used on board ship, but occasionally in casemates, and retired flanks of fortresses.

The highest charge is one-eighth the weight of the shot.
The lowest charge one-sixteenth do. do.

Note.—For Weights, Dimensions, Ranges, &c., vide Tables.

MORTARS.

Mortars differ from Guns in the construction of their bore, and also in their form, which is considerably shorter, the metal being much thicker, and the trunnions being at the extremity of the breech.

They are used for throwing Shells into a town, or battery, setting fire to and overthrowing works, blowing up magazines, and breaking through the roofs of barracks, casemates, magazines, &c. They are distinguished from each other by the diameter of their bore. Their chambers are in the form of a frustrum of a cone, in which the powder is more concentrated; the Shell fits close to the sides of the piece, and thereby receives the whole force of the expansion of the powder. The greatest charges their chambers will contain, and the corresponding Ranges, are as follows:—

	13-inch. Land Service.	10-inch. Land Service.	8-inch. Land Service.
Greatest charge	9 pounds.	4 pounds.	2 pounds.
Greatest range	2706 yards.	2536 yards.	1726 yards.

When Mortars are used in firing on Inclined planes, up or down hill, should the inclination be considerable, take half the angle it makes with the horizon, and add it to, or subtract it from 45 degrees (which is for a medium plane), and it will give *the greatest range upon the required plane.*

Note.—Vide Tables of Dimensions, Weight, Charges, Ranges, &c.

VALUE OF ORDNANCE.

BRASS ORDNANCE.

Dependent on the market price of metals; at present the value of gun metal is £180 a ton.

IRON ORDNANCE.

The value is variable according to the market price of iron; at present the value is £20 a ton.

PROOF OF ORDNANCE.

All natures of Ordnance undergo several kinds of proof before they are received into the service:—

1st. They are gauged as to their several dimensions, internal and external; as to the justness and position of the bore, the chamber, vent, and trunnions, &c.

2nd. They are fired with a regulated charge of powder and shot, being afterwards searched to discover irregularities, or holes produced by the firing.

3rd. By means of engines, an endeavour is made to force water through them.

4th. They are examined internally by means of light, reflected from a mirror.

IRON GUNS.

The guns are first examined as to their proper dimensions, in which no more than ·3 of an inch variation is allowed; and in the diameters of the bore only ·033; but in the position of the bore ·25 of an inch out of the axis of a piece is allowed.

They are then fired twice with the charge in the following table, with one shot and two high junk wads, and examined with a searcher after each round.

In this examination they must not have any hole or cavity in the bore of two-tenths of an inch in depth behind the first reinforce ring, or one-fourth of an inch in depth before this ring.

PROOF CHARGES.

Nature . .	10 In.	8 In.	68 Pr.	56 Pr.				
Charge, in pounds	20	18	28	28				
Nature . .	42 Pr.	32 Pr.	24 Pr.	18 Pr.	12 Pr.	9 Pr.	6 Pr.	3 Pr.
Charge, in pounds	25	21½	18	15	12	9	6	3

BRASS GUNS.

From 3 to 12 pounders the diameter of the bore must not vary more than ·025 of an inch, nor in any dimensions more than ·2.

PROOF CHARGES.

Nature . .	12 Pr.	9 Pr.	6 Pr.	3 Pr.
Charge . .	5 lb.	3½ lb.	2 lb.	1 lb.

The 12 and 9 pounders are fired twice, the remainder three times. Any hole ·15 of an inch upwards, or sideways in the bore, or ·1 in the bottom, between the breech and first reinforce; or ·2 of an inch upwards, or sideways, or ·15 in the bottom of the bore before the first reinforce ring, will be sufficient to condemn them.

MORTARS, AND HOWITZERS.

The exterior dimensions are in no respect to deviate more than ·1 of an inch in the 10, and 8 inch Howitzers, and ·05 of an inch in the 24, and 12 pounder Howitzers, and Royal and Coehorn Mortars, and Howitzers. Their bores and chambers must not deviate from their true diameters, or positions more than ·025 of an inch.

PROOF CHARGES.

The Brass Mortars, and Howitzers are fired twice with their chambers full of powder, and an iron shell. The Mortars on their own beds at an elevation of about 75 degrees, and the Howitzers on their carriages at an elevation of about 12 degrees. The Iron Mortars are proved with a charge equal to the full chamber, and a solid shot equal in diameter to the shell. Royal or Coehorn Mortars, and also 24, and 12 pounders, or Royal Howitzers, having a hole of ·1 of an inch in depth in the chamber, or ·15 of an inch in the chase are rejected. A hole ·15 of an inch in depth in the chamber, or ·2 of an inch in the chase is sufficient to condemn the 10, and 8 inch Howitzers. For the 13-inch Sea-service Mortar a cylinder weighing 4½ cwt. is used for proof.

CARRONADES.

The bores, and chambers of Carronades must not deviate more than ·05 of an inch from their true dimensions, and positions.

PROOF CHARGES.

They are proved with two rounds, with their chambers full of powder, and one shot and wad. A hole of ·2 of an inch in depth in the bore, or ·1 in the chamber condemns the piece.

WATER PROOF.

All Ordnance, after having undergone the before-mentioned proofs, and the subsequent searchings, are subject to the *Water proof*. This is done by means of a forcing pump, having a pipe or hose fitted and secured to the mouth of the piece, and a plug to stop up the vent.

After two or three efforts to force the water through any honeycombs, or flaws, which there may be in the bore, they are left to dry, and generally the next day examined by light reflected from a mirror. If the bore should contain any small holes, or flaws which have not been discovered by the former proofs, they are very readily found by this, as the water will continue to weep or run from the holes, after the solid parts of the bore are perfectly dry.

When a gun bursts in proving, the remainder in proof at the same time are subjected to another proof round.

Ordnance condemned, for any of the foregoing reasons as unserviceable, is marked as follows:—

D × for faulty in dimensions.
S × by Searcher. W × by Water proof.

Condemned Shells are thus marked:—
F — for Fuze-hole faulty.
N × for Non-concentric. W × for Water proof.

INSTRUCTIONS FOR THE CARE, AND PRESERVATION OF IRON ORDNANCE.

Great attention should be paid to the care and preservation of iron Ordnance when in Depôt, or on Service, to prevent the irreparable injury Guns sustain from rust and corrosion.

With this view the first step to be taken is to clear their bores and exterior surfaces from all rust and dirt, which is done on the inside with circular Spring Scrapers, fixed on the end of a long shaft or handle: these scrapers are made to press strongly on the sides of the cylinder, and by being drawn backwards and forwards by two or three efficient labourers, will remove the rust, and, if not in a very bad state, will restore a regular smooth surface; the bottom or end of the bore is also scraped with a tool for that purpose, and the vent is opened by passing a square steel rimer of its diameter through it, gently turning the tool round until the vent is clear; after which the bore must be well brushed out, first with a hard round brush, and then with a Turk's-head brush, so that not the least dirt remains in it. This being performed, the first coat of lacquer may be laid on, to which, when dry, a second is to be added. This is done with a common painter's brush, fixed vertically on the end of a staff sufficiently long to reach down the cylinder; and the bottom of the bore is lacquered by another brush fixed horizontally at the end of the staff; the outside or exterior parts of the pieces are also to be well scraped with an old sea-service sword, or steel tool of that nature, tolerably sharp, especially about the mouldings, where former coatings and dirt have accumulated; and when the rust will not give way, it should be slightly hammered, so as to loosen it. These operations must be continued until the whole coat of old paint, rust, or dirt, is completely removed, after which the dust must be well brushed or rubbed off, and the piece will then be fit to receive its first coat of anticorrosion, to which, when dry, a second is to be added.

Before the work is commenced the pieces should be arranged as nearly as possible in the places where they are to remain, as too much rolling is apt to disturb the coating of paint, especially before it has gained sufficient hardness to be durable.

The following objects also require to be particularly attended to—viz.:

In skidding Guns, &c., care must be taken that they are laid under metal, so that their muzzles may be sufficiently inclined downwards to prevent rain or any moisture lodging, and the bores from time to time should be swept out, as dust or sand blowing into them and being suffered to remain, would be very destructive; nor should the Guns be ever stacked one over the other, if the space where they are kept is sufficiently large to admit of their being laid in single tiers.

After the Ordnance is once got into a complete state of preservation, by following these instructions, very little trouble or expense will attend their being kept so, for a slight coat of anticorrosion on the exterior, and a thin coat of lacquer in the cylinder every three or four years, is all they will require, provided they are every now and then brushed out as before stated.

On coating the Guns, it may be found useful to let the painter mark on them the date, which will show how long it lasts, as this may differ at different stations, especially such as are exposed to much damp air, and it will afford the means of calculating the necessary demands of articles for this purpose at stated periods.

The same rules are to be observed in the preservation of all iron Ordnance mounted on works, with regard to the application of lacquer, and anticorrosion, and the precautions of keeping the pieces laid under metal, and frequently brushing out their bores, &c., as recommended in the foregoing instructions.

MIXTURE OF INGREDIENTS FOR COATING, AND LACQUERING IRON ORDNANCE.

	lb.		lb.
Anticorrosion	40	Red lead, as a drier	3
Black (Grant's) ground in oil	4	Linseed oil, gallons 4	
		Turpentine (spirits of), pint 1	

This mixture, when well stirred, and incorporated, will be fit for use, but, as by long keeping in this state it becomes hard, no more should be mixed than is required for present use.

BLACK LEAD LACQUER, FOR THE BORE, OR CYLINDER.

	lb.		lb.	oz.
Black lead (Cumberland)	9	Red lead	2	8
Linseed oil, gallons 4		Lamp black, or wad	0	4

The oil to be boiled, and the paint to be well ground. This will keep. Great care should be taken in boiling the oil, as any damp falling in would cause an explosion.

INSTRUCTIONS FOR LACQUERING SHOT, AND SHELLS.

All Shot, and Shells (including Shrapnel) are first to be cleaned exteriorly by the machine, or otherwise, and then such as are found sufficiently correct, and up to their proper gauge, are to be twice lacquered with the following composition, leaving sufficient time between for the coats to become perfectly dry, and hard. The warmest weather is the proper time for this operation. Ten labourers can examine, clean, and lacquer with two coats one thousand shot in a day, provided the weather be favourable.

COMPOSITION.

Grant's black 40lb. Red lead 5lb. Raw linseed oil 5 gallons.

The red lead is to be ground into a part of the oil, in order that the whole of the ingredients may be thoroughly incorporated.

TO RENDER ORDNANCE UNSERVICEABLE BY SPIKING, ETC.

The most effectual method of rendering Guns unserviceable, or of no further use, is by removing one or both of the trunnions, which may be done by striking it near its end with a sledge hammer; or by firing a shot against it from a carronade, or howitzer, the muzzle of the piece being placed near the trunnion.

Brass Ordnance may also be rendered unserviceable by firing whole or broken shot into the bore from another piece; or by firing a shot against the chase, which generally bulges the metal within the bore.*

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* *When a shot is jammed in a gun, and cannot be rammed home to the cartridge,* destroy the charge by pouring water down the vent and muzzle, until the ingredients are dissolved, and cleared out of the bore; then introduce a small quantity of powder through the vent, and blow out the shot.

For spiking Ordnance, two kinds of spikes are used:—

1st. *The Common spike*, which is 4 inches long, ·27 inches in diameter at the head, and about ·1 at the point. It is driven as far as it will go into the vent, and afterwards broken off close to the gun.

2nd. *The Spring, or temporary spike*, which is ·17 in diameter, and varies in length from 2·8 to 13·55 inches, according to the nature of the piece. It has a flat head to prevent its falling through the vent into the bore, and also a spring about two inches in length, which extends from the point towards the head. In passing through the vent, this is compressed, but as soon as it is clear of the metal, it expands and cannot be withdrawn, unless it is again compressed sufficiently to allow its being again drawn into the vent, which may be done by pressing a rammer head against it, provided the spring is towards the muzzle, which may be known by a small notch cut in the head of the spike to point out its direction.

A long spike with a soft point may be driven into the vent, and the end projecting into the bore clenched; which, as well as either a common nail or even a wooden peg, would answer as a temporary expedient if a proper spike were not at hand. Should a momentary abandonment of the guns become unavoidable, by taking away the cap-squares, elevating screws, quoins, linch-pins, or side-arms, the enemy will be prevented using them for some time.

UNSPIKING ORDNANCE.

If a gun has been spiked with a Common steel spike, load with a charge of powder equal to half the shot's weight: lay a leader of quick match along the bore, and double shot the gun, introducing the shot, however, very carefully.

By affixing a piece of slow match to the end of the quick match which reaches to the muzzle, the gun may be easily and safely fired. Should the spike not be removed, the operation may be repeated.

When Brass guns have been spiked, it would be advisable, a day or two before making the above experiment, to scratch round the spike with a graver, and pour a few drops of Sulphuric, or Nitric acid into the circle, which, being repeated, will find its way down between the spike, and the metal, particularly if the former is not perfectly round. When the gun cannot be unspiked by the above-mentioned operations, make a large fire round the breech to soften the spike, and after the gun has been gradually cooled, the spike may generally be removed by using the drill.

When a gun cannot be unspiked, the only means of rendering it serviceable is to drill another vent, about half an inch from the original one.

To drill a new Vent will require about an hour per inch. Care must be taken that a very small drill is first used, and afterwards one rather less than the diameter of the vent, otherwise the vent will run the risk of being too much enlarged.

Length, Weight, Calibre, Charge, &c., of Ordnance.

Nature of piece.	Length.		Weight.	Calibre.	Charges, Land Service.		Shot.	
	In feet and inches.	In calibres.			Service.	Proof.	High gauge.	Low gauge.
		ft. in.	cwt.	inches.	lb. oz.	lb. oz.	inches.	inches.
10-Inch	9 4	11·	87	10·	12 †	20	9·87	9·82
8·	9	13·3	65	8·05	10 †	20	7·95	7·9
	8 10	13·05	60	8·05	10 †	18	,,	,,
	8	11·82	52	8·05	8 †	16	,,	,,
	6 8	9·93	50	8·05	8 †	14	,,	,,
68 Pr.	10 10	16·15	112	8·12	18	30	,,	,,
	10	14·78	95	8·12	14	28	,,	,,
	9 6	14·	87	8·12	14	25	,,	,,
56 Pr.	11	17·6	98	7·65	14	28	7·51	7·45
	10	16·	87	7·65	14	25	,,	,,
42 Pr.	10	17·21	84	6·97	14	25	,,	,,
	10	17·21	75	6·97	14	25	6·79	6·73
	9 6	16·43	67	6·93	10	23	,,	,,
32 Pr.	9 7	17·95	64	6·41	10	21 5	6·2	6·14
	9 6	17·78	56	6·41	10	21 5	,,	,,
	9 6	17·78	58	6·41	10	21 8	,,	,,
A	9 0	17·12	50	6·41	8	18	,,	,,
	9	16·35	46	6·35	6	12	,,	,,
B	8 6	16·	45	6·35	7	16	,,	,,
	8 0	14·9	50	6·41	8	21 8	,,	,,
	8	14·9	48	6·41	8	21 8	,,	,,
C	8	15·1	42	6·35	6	14	,,	,,
*	7 6	14·1	40	6·35	6	12	,,	,,
	7 6	14·04	39	6·35	6	12	,,	,,
*	6 6	12·38	32	6·3	5	10	,,	,,
	6	11·4	25	6·3	4	9	,,	,,
24 Pr.	9 6	19·57	50	5·82	8	18	5·63	5·58
	9	18·54	48	5·82	8	18	,,	,,
	6 6	13·39	33	5·82	4	12	,,	,,
18 Pr.	9	18·52	42	5·29	6	15	5·12	5·07
	8	18·14	38	5·29	6	15	,,	,,
*	7	16·24	22	5·17	3	7	,,	,,
*	6	13·92	20	5·17	3	7	,,	,,
*	5 6	12·76	15	5·17	2	5	,,	,,
12 Pr.	9	23·14	34	4·62	4	12	4·54	4·50
	8 6	22·	33	4·62	4	12	,,	,,
	7 6	19·46	29	4·62	4	12	,,	,,
	6	15·57	21	4·62	4	10	4·50	4·50
9 Pr.	8 6	24·28	28	4·2	3	9	4·11	4·08
	7 6	21·4	26	4·2	3	9	,,	,,
	7	20·	25	4·2	3	9	,,	,,
	5 6	15·71	17	4·2	2	8	,,	,,
6 Pr.	8 6	27·86	23	3·66	2	6	3·58	3·55
	7 6	24·53	21	3·66	2	6	,,	,,
	6	19·6	17	3·66	2	6	3·56	3·55

* Bored-up guns. † Hollow shot.

Length, Weight, Calibre, Charge, &c., continued.

	Nature of piece.	Length.			Weight.	Calibre.	Charge.				Shot* Shell.	
		In feet and inches.		In Calibres.			Service.		Proof.		High gauge.	Low gauge.
		ft.	in.		cwt.	inches.	lb.	oz.	lb.	oz.	inches	inches.
CARRONADES.	68 Pr.	5	4	7·9	36	8·05	5		13		7·95	7·9
	42	4	6	7·8	22	6·84	3	8	9		6·79	6·72
	32	4		7·6	17	6·25	2	10	8		6·2	6·14
	24	3	9	7·9	13	5·68	2		6		5·63	5·58
	18	3	4	7·7	10	5·16	1	8	4		5·12	5·07
	12	2	8	7·	6	4·52	1		3		4·47	4·43
	6	2	9	9·1	4½	3·6		10	1	8	3·56	3·53
IRON HOWITZERS.	10-inch	5		6·	40	10·	7		12		9·88	9·8
	8	4		6·	20	8·	4		8		7·9	7·82
	5½	3	4	7·1	15	5·62	2	8	6		5·62	5·57
IRON MORTARS.	13-inch	4	5	4·	100	13·			20	11	12·88	12·8
	13	4	5	4·	82	13·			16		12·88	12·8
	13	3	11	3·6	36	13·			9		12·88	12·8
	13	3	5	2·8	36	13·			9		12·88	12·8
	10	3	9	4·5	52	10·			9	8	9·88	9·8
	10	3	9	4·5	41	10·			9	8	9·88	9·8
	10	2	9	2·5	18	10·			4		9·88	9·8
	10	2	4	2·8	16	10·			4		9·88	9·8
	8	2	2	3·2	9	8·			2		7·9	7·82
	8	1	10	2·7	8	8·			2		7·9	7·82
BRASS GUNS.	12 Pr.	6	6	17·	18	4·62	4		5		4·47	4·43
	9 Pr.	6		17·	13½	4·2	2	8	3	8	4·1	4·06
	6	5		16·3	6	3·66	1	8	2		3·56	3·53
	3	4		16·4	3	2·91		12	1		2·83	2·8
	3	3		12·3	2¼	2·91		10	1		2·83	2·8
	1	5		29·8	2½	2·01		6		12	1·99	1·92
BRASS HOWITZERS.	32 Pr.	5	3	10·5	18	6·3	3	0	4	0	6·2	6·1
	24	4	8·6	9·8	13	5·72	2	8	2	8	5·62	5·57
	12	3	9·2	9·8	6½	4·58	1	4	1	4	4·47	4·43
	4⅖	1	10	4·8	2½	4·52		8	1	0	4·47	4·43
BRASS MORTARS.	10-inch	2	3	2·7	12¼	10·			4		9·88	9·8
	8	1	9	2·6	6½	8·			2		7·9	7·82
	5½	1	3	2·6	1¼	5·62				7	5·62	5·57
	4⅖	1	0	2·6	¾	4·52				5	4·47	4·43

* Shot for guns: Shells for howitzers, and mortars.

CARRIAGES.

Garrison carriages are made of oak and other hard wood. *Trucks* iron; but in those situations which are not exposed to enfilade, the carriages are cast iron.

Ship carriages.—The *Brackets* and *Transoms* are elm, *Axletrees* oak, *Trucks* elm.

Field gun carriages.—All Travelling carriages are now made entirely of oak. *The Carriages,* for the heavy iron 12 and 9-pounders with bracket-trail, and also for all heavy battering ordnance, are made of oak. *Limbers* have the axletree beds of elm; *Futchells, Splinter,* or *Sweeping-bar,* of ash; *Footboards,* fir or elm. *Limber-boxes* have the sides elm, and the rest fir. *Ring-tires* are used for light 3-pounders and hand-cart wheels. *Shafts* are always made of ash. *Wheels* have the *Nave* of elm, *Spokes* (12) of oak, *Felloes* (6) of ash.

Sleighs are used for the conveyance of artillery, during the winter, in Canada.* The sleigh consists of a platform six feet ten inches long, and three feet ten inches wide, placed on runners sixteen inches high; upon this rest two strong transoms, to which the brackets supporting the gun are secured. A box, distinct from the ammunition boxes, is placed on each side of the gun, together capable of containing about thirty rounds of ammunition, and which serve as seats for Nos. 1 and 6. These boxes usually contain the shot, and small stores carried in the axletree boxes, as well as long reins for driving, when in single draught. The extreme breadth of the runners is three feet.

Packing the Intrenching tools, &c.

Marching order.—In marching order, the following stores and intrenching tools are *on the gun sleighs;* two fitting ropes, one spare swingletree; swords of Nos. 1 and 6 on front platform under breast of gun, claw hammer, wrench, and pincers; in sockets, two portfire sticks on right rear of platform.

On No. 1 *ammunition sleigh;* two fitting ropes, prolonge, two spare swingletrees, and sword of No. 3, on front part of platform; carbines of No. 1 and 6, on front box; spare sponge, and worm on platform right of boxes; spare handspike on left side; 4 spare traces between front and rear boxes; swords of Nos. 4 and 5 on platform in rear of boxes, covered by knapsacks of Nos. 1, 6, 5, and 4. The knapsacks are strapped from off-handle of off-box to rear handle of rear-box.

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* The recoil of guns on sleighs varies from four to five feet when on rough ground or in deep snow; to twenty or thirty yards when on glare ice. In the latter case it is of course necessary to send the ammunition sleighs further to the rear; but the recoil may be considerably lessened by placing a small chain round each of the runners.

Ice of eight inches thick will bear with safety a weight of 1115 lb. (or nearly half a ton) on the square foot.

On No. 2 *sleigh;* felling axe, and two camp kettles, on front of platform; sword of No. 2 on front box; pickaxe in rear of front box; four spades strapped to front of rear boxes; four water buckets strapped to guard irons of front box, two at each side; swords of Nos. 7 and 8 in rear of boxes, covered by knapsacks of Nos. 2, 3, 7, and 8.

DEPRESSION CARRIAGES.

Of these there are two descriptions—

1st. Those in the batteries at Gibraltar.
2nd. Those constructed for general service.

These latter carriages are similar to common standing carriages, excepting that they are about a foot longer, and the front transom is hollowed so as to allow of a greater depression, and has a bolt behind it for the end of the stool bed. There is also a skid, or transom, placed across the last step of the carriage, which has a thread in it for the elevating screw that supports one end of the stool bed. These carriages admit of a depression of 30°, but after every round the piece must be brought horizontal to load, which is done by taking out altogether the rear transom. *Depression Carronade carriages* differ from the common carriages in having their trucks in rear instead of in front. They are depressed by an iron segment of a circle, which is moveable in a slit in the trail, and which has holes in it about an inch apart, through which a bolt is to be placed to support it at any height, the intermediate depression being given by a screw.

CARRIAGES; FIELD, TRAVELLING.

Spare wheels are not included in the following Table of weights.

		Weight. cwt.	qrs.	lb.	Total. cwt.	qrs.	lb.
18 Pr. Gun	Carriage . . .	17	1	0	28	3	8
	Limber . . .	10	0	14			
	Side Arms . .	1	1	22			
18 Pr. Ammunition Waggon	Body . . .	11	1	14	22	0	4
	Limber . . .	9	0	27			
	Side Arms . .	1	1	19			
12 Pr. Medium Gun	Carriage . . .	13	0	0	24	0	18
	Limber . . .	10	0	0			
	Side Arms . .	1	0	18			
12 Pr. Ammunition Waggon	Body . . .	11	1	8	22	0	26
	Limber . . .	9	0	18			
	Side Arms . .	1	3	0			
Spare Gun Carriage 12 Pr.	Body . . .	13	1	0	27	3	14
	Limber . . .	8	3	11			
	Spare Articles .	5	3	3			
32 Pr. Howitzer	Carriage . . .	14	2	0	25	3	16
	Limber . . .	10	0	22			
	Side Arms . .	1	0	22			
32 Pr. Howitzer Ammunition Waggon	Body . . .	11	1	12	22	1	24
	Limber . . .	9	1	24			
	Side Arms . .	1	2	16			
9 Pr. Gun	Carriage . . .	12	0	0	22	0	24
	Limber . . .	9	0	10			
	Side Arms . .	1	0	14			
Ammunition Waggon 9 Pr.	Body . . .	11	1	12	22	0	18
	Limber . . .	9	0	10			
	Side Arms . .	1	2	24			
Spare Gun Carriage 9 Pr.	Body . . .	12	1	0	26	2	15
	Limber . . .	8	3	11			
	Spare Articles	5	2	4			
24 Pr. Howitzer	Carriage . . .	14	0	0	24	1	13
	Limber . . .	9	1	2			
	Side Arms . .	1	0	11			
24 Pr. Howitzer Ammunition Waggon	Body . . .	11	1	4	21	3	14
	Limber . . .	9	0	2			
	Side Arms . .	1	2	8			
6 Pr. Gun	Carriage . . .	10	1	0	20	0	26
	Limber . . .	8	3	18			
	Side Arms . .	1	0	8			
6 Pr. Ammunition Waggon	Body . . .	11	0	16	21	2	21
	Limber . . .	8	3	18			
	Side Arms . .	1	2	25			

		Weight. cwt.	qrs.	lb.	Total. cwt.	qrs.	lb.
Spare Gun Carriage 6 Pr.	Body . . .	10	2	0	24	3	11
	Limber . . .	8	3	11			
	Spare Articles .	5	2	0			
12 Pr. Howitzer	Carriage . .	11	1	0	21	1	18
	Limber . . .	9	0	14			
	Side Arms . .	1	0	4			
Ammunition Waggon 12 Pr. Howitzer	Body . . .	11	1	14	22	0	8
	Limber . . .	9	0	14			
	Side Arms . .	1	2	8			
3 Pr. Colonial service Gun 4 feet	Carriage . .	4	0	3	7	3	7
	Limber . . .	3	3	4			
	Car	3	3	14	3	3	14
4⅖ in. Howitzer	Carriage . .	5	1	2	8	2	18
	Limber . . .	3	1	16			
Limber 4⅖ in. Howitzer	Carriage . .	3	3	20	3	3	20
1 Pr. Mountain service, Gun	Carriage . .	2	3	2	3	1	22
	Four small boxes		2	20			

		Weight. cwt.	qrs.	lb.	Total. cwt.	qrs.	lb.
Carried on the backs of 2 mules	Two large boxes		2	4		2	4
Forge Waggon	Body . . .	8	3	0	24	0	26
	Limber . . .	8	3	11			
	Frame with Bellows, Coal Boxes, Anvil, Vice, Hoops, and Covers .	6	2	15			
Carriages Rocket	12 Pounder .	20	2	8	20	2	8
	6 „ .	20	1	20	20	1	20
Store Waggon	Body . . .	11	1	0	20	0	11
	Limber . .	8	3	11			
Carts	Store . . .	11	3	0	11	3	0
	Medicine . .	11	3	10	11	3	10
Pontoon, and Carriage. Infantry	Carriage . .	9	3	17	25	2	18
	Pontoons . .	5	3	26			
	Appurtenances.	9	3	3			

CARRIAGES; SIEGE, TRAVELLING.

		Weight.		
		cwt.	qrs.	lb.
8 Inch 52 Cwt..	Carriage	25	1	0
	Limber	10	0	14
32 Pr. 56 Cwt.	Carriage	24	0	0
	Limber	10	0	14
24 Pr. 50 Cwt.	Carriage	23	3	25
	Limber	10	0	14
10 Inch Howitzer	Carriage	31	2	10
	Limber	10	0	14
8 Inch Howitzer	Carriage	25	2	14
	Limber	10	0	14

GYN TRIANGLE.

	cwt.	qrs.	lb.
18 Feet, with New Pattern Windlass	11	3	20

PLATFORMS.

			cwt.	qrs.	lb.
Portable, Capt. Clerk's pattern			14	0	22
Dwarf Traversing	Wood	10″ or 68 Pr.	32	2	27
		8″ 32, or 24 Pr.	24	2	21
		Do. Casemate	21	0	17
	Iron	8″ 32, or 24 Pr.	50	0	0

CARRIAGES, GARRISON.

			cwt.	qrs.	lb.
Dwarf	Platforms Wood	10″, or 68 Pr.	17	1	25
		8 Inch	14	0	0
		32 Pr.	13	3	26
	Platforms Iron	8 Inch	14	0	0
		32 Pr.	13	3	26
		24 "	13	0	6
Common Standing		8 Inch	15	0	0
		32 Pr.	15	2	0
		24 "	13	2	0
		18 "	12	1	1
		12 "	11	0	0
		9 "	10	1	13
		6 "	9	0	20
Rear Chock		10″, or 68 Pr.	15	2	20
		8″ {65 52} Cwt.	13	0	22
		32 Pr.	13	2	12

CARTS. GENERAL SERVICE.

	Weight.		
	cwt.	qrs.	lb.
Forage, Military Train	7	2	26
Hand	4	3	0
Sling	17	3	24
Trench	5	2	13
Maltese	5	1	22
Ditto, fitted with Portable Forge, Frame, Bellows, Anvil and Block, Vice, Tool, and Coal Boxes	12	0	9

WAGGONS. GENERAL SERVICE.

		cwt.	qrs.	lb.
Military Train		13	3	0
Ambulance		12	2	0
Bread		13	1	26
Platform		21	3	18
Sling		33	2	5
Small Arm Ammunition	Body	8	1	25
	Limber	9	0	0

WHEELS.

			Height.		Weight.		
			ft.	in.	cwt.	qrs.	lb.
1st Class	Howitzer, 10, or 8 Inch; also 8 Inch of 52 Cwt. 32, 24, or 18 Pr. Guns		5	0	4	1	5
	Sling	Waggon	7	0	5	3	6
		Cart	5	6	4	2	20
2nd Class	9 Pr. heavy for Carriages, and Limbers of 32 Pr. Howitzer, and 12 Pr. Brass Guns. Body 9 Pr. Brass, and 12 Pr. Iron Guns, and 24 Pr. Howitzer Carriages		5	0	2	1	12
	Platform Waggon	Fore	4	0	2	0	9
		Hind	5	0	3	0	0
	Limbers for	Siege Carriage	4	0	2	0	9
		Sling Waggon	5	0	3	0	0
	9 Pr. light, used for 6 Pr. Gun, and 12 Pr. Howitzer Carriages, and Limbers. Body 9 Pr. Gun, and 24 Pr. Howitzer Limbers, and all Ammunition and Store Waggons and Carts, for a Troop, or Battery R. A.: also large Pontoon Carriage, Hind		5	0	1	3	23
	Limbers	Pontoon Carriage 12 Pr. Iron Gun	4	2	1	2	26

WHEELS—*continued.*

		Height.		Weight.		
		ft.	in.	cwt.	qrs.	lb.
3rd Class	General Service Wheel, used by all Carriages of the Military Train, Cavalry Forge Carts; Forage Waggons R. A.; Royal Engineers Equipment; Ambulance, and Infantry Pontoon Waggon; 3 Pr. and 4⅖ Inch Howitzer Carriages, and Limbers	4	2	1	0	16
4th Class	3 Pr., and 4⅖ Inch Howitzer, Mountain Service	3	0	0	2	10
	Barrows, Ammunition	2	6	0	1	12

AXLETREES.

			Weight.		
			cwt.	qrs.	lb.
1st Class Arm		10, or 8 Inch Howitzer; also 8 Inch of 52 Cwt. or 32, 24, or 18 Pr. Guns . . .	1	3	9
	Sling	Waggon	2	0	3
	Sling	Cart	1	3	8
2nd Class		9 Pr. Heavy, used for Carriages and Limbers of 32 Pr. Howitzer, 12 Pr. Brass Guns, and Platform Waggons, Body 9 Pr. Brass, and 12 Pr. Iron Gun, and 24 Pr. Howitzer Carriages	1	0	17
	Limbers	Sling Waggon			
	Limbers	Siege Carriage			
		9 Pr. light, used for 6 Pr. Gun 12 Pr. Howitzer, and large Pontoon Carriages and Limbers. For Limbers of 9 Pr. Heavy, and all Ammunition, and Store Waggons, and Carts for a Battery, or Troop, and Limbers for 12 Pr. Iron Gun	0	3	16
		Carts, Trench	0	2	17
3rd Class		Carts, hand	0	1	21
	Carts	Forage	0	2	4
	Carts	Forge, and Maltese			
	Waggons	Ambulance, Bread, Infantry Pontoon, and General Service, including Engineer Equipt. and Artillery Forage Waggons			
		3 Pr. of 4 Feet, and 4⅖ Inch Howitzer Carriages, Waggons, and Limbers Colonial Service	0	1	9½
4th Class		3 Pr. of 3 Feet, and 4⅖ Inch Howitzer, Mountain Service	0	0	20
		Barrows, Ammunition	0	0	16

Weight, and Dimensions of Trucks, for Land Service.

Nature of Trucks.	Fore.							Hind.							
	Diameter.			Width of sole.	Weight of a pair.			Diameter.			Width of sole.	Weight of a pair.			
	Truck.		Hole.					Truck.		Hole.					
	ft.	in.	in.	in.	cwt.	qrs.	lb.	ft.	in.	in.	in.	cwt.	qrs.	lb.
42 Pr.	1	7	7·5	6·62	3	0	20	1	4	7·5	5·	2	0	4
32	1	7	7·5	6·62	3	0	20	1	4	7·5	5·5	2	0	4
24	1	7	6·5	5·	2	1	26	1	4	6·5	4·5	1	2	5
18	1	7	6·5	5·	2	1	26	1	4	6·5	4·5	1	2	5
12	1	7	6·5	5·	2	1	26	1	4	6·5	4·5	1	2	5
9	1	7	6·5	5·	2	1	26	1	4	6·5	4·5	1	2	5
6	1	6	5·5	4·25	1	3	4	1	4	6·5	3·5	1	1	6
3	1	6	5·5	4·25	1	3	4	1	4	6·5	3·	1	1	6

Weight, and Dimensions of Mortar Beds.

OLD PATTERN.

Nature of Bed; Land service.	Weight.			Dimensions.					
				Length.		Breadth.		Height.	
	cwt.	qrs.	lb.	ft.	in.	ft.	in.	ft.	in.
13 Inch . . Iron . .	35	2	22	5	5½	3	1	2	1
10 Inch . . Iron . .	16	1	16	4	4	3	1	1	7
8 Inch . . Iron . .	7	2	27	3	3	3	1	1	3
5½ Inch . . Wood . .	1	0	10	2	7	1	3		9
4⅔ Inch . . Wood . .		3	5	2	5	1	3		

NEW PATTERN.

Nature of Bed; Land service.	Weight.			Dimensions.					
				Length.		Breadth.		Height.	
	cwt.	qrs.	lb.	ft.	in.	ft.	in.	ft.	in.
13 Inch . . Iron . .	35	2	20	6	1	3	2¾	2	½
10 Inch . . Iron . .	17	3	16	4	4	3	1	1	7
8 Inch . . Iron . .	8	3	3	3	3	3	1	1	3

The Breadth and Length of each Bed are measured from the extremities of the traversing bolts.

RANGE, ELEVATION, ETC., OF BRASS ORDNANCE.

SOLID SHOT.			COMMON CASE SHOT.*		
Elevation.	12 Pr. 9 Pr. Long 6 Pr.	Light 12 Pr. Ditto 6 Pr. Heavy 3 Pr.	Elevation.	12 Pr. 9 Pr.	6 Pr.
degrees.	yards.	yards.	degrees.	yards.	yards.
P. B.	300	200	P. B.	150	100
¼	400	300	¼	175	125
½	500	400	½	200	150
¾	600	500	¾	225	175
1	700	600	1	250	200
1¼	775	650	1¼	275	225
1½	850	700	1½	300	250
1¾	925	750	1¾	325	275
2	1000	800	2	350	300
2¼	1050	850			
2½	1100	900			
2¾	1150	950			
3	1200	1000			
3¼	1250	1050			
3½	1300	1100			
3¾	1350	1150			
4	1400	1200			

24 Pr. Howitzer. Charge 2½ lb.					12 Pr. Howitzer. Charge 1½ lb.					5½ in. Howitzer.	Heavy 2 lb.	Light. Charge 1 lb.
Com. Shells.			C. Case.		Com. Shells.			C. Case.		Com. Shells.		
Elevation.	Fuze.*	Range.	Elevation.	Range.	Elevation.	Fuze.*	Range.	Elevation.	Range.	Elevation.	Range.	Range.
deg.	10ths	yds.	deg.	yds.	deg	10ths	yds.	deg.	yds.	deg.	yds.	yds.
P. B.		250	P. B.	150	1	1	400	P. B.	100	P. B.	250	150
¼		300	¼	175	1¼	1½	450	¼	125	1	400	300
½		350	½	200	1½	2	500	½	150	2	550	450
¾		400	¾	225	1¾	2½	550	¾	175	3	700	600
1	1	450	1	250	2	3	600	1	200	4	850	750
1¼	1½	500	1¼	275	2¼	3½	650	1¼	225	5	975	850
1½	2	550	1½	300	2½	4	700	1½	250	6	1100	950
1¾	2½	600	1¾	325	2¾	4½	750	1¾	275	7	1225	1050
2	3	650	2	350	3	5	800	2	300	8	1350	1150
2¼	3½	700	2¼	375	3¼	5½	850			9	1450	1200
2½		750	2½	400	3½	6	900			10	1550	1250
2¾	4½	800			3¾	6½	950			11	1650	1300
3	5	850			4	7	1000			12	1750	1350
3¼	5½	900			4¼	7¼	1025					
3½	6	950			4½	7¾	1050					
3¾	6½	1000			4¾	8	1075					
4	7	1025			5	8¼	1100					
					5¼	8½	1125					
					5½	8¾	1150					

* Fuze—Old pattern.

Ranges, Elevation, &c., of 8-*inch Howitzer.*

Common Shells.				Shrapnel Shells.		Ricochet firing.			
Charge.	Fuze.	Elevation.	Range.	Fuze.	Elevation.	Charge.	Elevation.	Range.	Fuze.
lb.	inches.	deg.	yards.	inches.	deg.	lb.	deg.	yards.	inches.
4	·3	2	450	..	..	..	..	..	..
	·4	2½	600	·3	2⅝	1	9·5	400	·85
	·52	3	750	·5	3½	1·5	6·	400	·8
	·65	3¾	900	·7	4½	1·5	9·	600	1·
	·8	4½	1050	·9	5⅝	2	6·25	600	·9
	·95	5⅜	1200	1·1	6⅞	2·5	5·5	600	·75
	1·1	6¼	1350	1·35	8¼	2	8·5	800	1·2
	1·3	7¼	1500	1·6	9¾	2·5	6·25	800	1·
	1·5	8¼	1650						
	1·75	9⅜	1800			1	34·5	1170	
	2·	10½	1950			2	34·5	2010	
	2·3	11¾	2100						
	2·6	13	2250			3	5	900	
	3·	14⅜	2400			3	10	1200	
	3·4	15¾	2550			3	15	1930	
	3·9	17¼	2700						

32 *Pr. Brass Howitzer.*

Range.	Common Case.	Common Shell.		Shrapnel Shell.		Range.	Common Case.	Common Shell.		Shrapnel Shell.	
Yards.	Elevation.	Elevation.	Fuze.	Elevation.	Fuze.	Yards.	Elevation.	Elevation.	Fuze.	Elevation.	Fuze.
200	P B					1150		4⅜	·8	4¼	
300	1°					1200		4⅞	·9	4⅝	·8
400	2°	¾	·2	P B		1250		5½	·9	5	
450		⅞	·2	¼	·2	1300	..	..	·9	5¼	·9
500		1°	·2	½		1350	..	..	1·0	5⅝	
550		1¼	·3	1°		1400	..	..	1·0	6°	1·0
600		1⅜	·3	1¼		1450	..	..	1·1	6¼	
650		1½	·3	1⅝	·3	1500	—	7½	1·1	6⅝	
700		1¾	·4	2°		1550			1·2	7°	
750		2°	·4	2½		1600			1·3	7¼	
800		2¼	·5	2	·4	1650			1·4	7⅝	
850		2½	·5	2¾		1700			1·5	8°	
900		2¾	·6	3°	·5	1750			1·6		
950		3°	·6	3¼		1800	—	9½	1·7		
1000		3¼	·7	3½	·6	1850			1·8		
1050		3⅝	·7	3¾		1900			1·9		
1100		4	·8	4°	·7	2000			2·0		

Range, Elevation, &c., of Brass Ordnance.

SHRAPNEL SHELLS.

12 Pr. Shell filled 10 lb. 13¼ oz. Shell empty 5 lb. 10 oz. Number of Balls . . 63

Letter & Length of Fuze.		Elevation.	Range	
			from	to
in.	10ths.	deg.	yds.	yds.
B	·2	1⅜	660	960
C	·3	1⅞	820	1110
D	·4	2¼	960	1230
E	·5	3¼	1080	1340
	·6	3½	1195	1445
	·7	3¾	1301	1545
	·8	4⅜	1415	1645
	·9	5⅛	1520	1740
1	·	5½	1620	1830
1	·1	6⅜	1720	1920
1	·2	7	1815	2005
1	·3	7⅝	1905	2085
1	·4	8¼	1990	2160
1	·5	8⅞	2070	2230
1	·6	9⅜	2140	2290
1	·7	10	2200	2340

9 Pr. Shell filled 8 lb. 1¼ oz. Shell empty 4 lb. 9¼ oz. Number of Balls . . 41

Letter & Length of Fuze.		Elevation.	Range	
			from	to
in.	10ths.	deg.	yds.	yds.
B	·2	1⅜	640	920
C	·3	1⅞	800	1060
D	·4	2¼	930	1180
E	·5	2¾	1050	1290
	·6	3¼	1160	1390
	·7	3¾	1260	1480
	·8	4⅜	1360	1570
	·9	5⅛	1455	1655
1	·	5½	1550	1740
1	·1	6⅜	1640	1820
1	·2	7	1725	1895
1	·3	7⅝	1805	1965
1	·4	8¼	1885	2035
1	·5	8¾	1960	2100
1	·6	9⅜	2030	2160
1	·7	10	2095	2215
1	·8	10¼	2165	2275

Light 6 Pr. Shell filled 5 lb. 7¼ oz. Shell empty 3 lb. 2 oz. Number of Balls . . 27

Letter & Length of Fuze.		Elevation.	Range	
			from	to
in.	10ths.	deg.	yds.	yds.
		1	380	640
B	·2	1¼	570	800
C	·3	1⅝	720	930
D	·4	2¼	845	1045
E	·5	2⅞	955	1145
	·6	3⅜	1060	1240
	·7	4	1160	1330
	·8	4⅝	1255	1415
	·9	5¼	1345	1500
1	·	5⅞	1430	1580
1	·1	6⅜	1510	1655
1	·2	7¼	1585	1725
1	·3	7⅝	1655	1785
1	·4	8¼	1720	1840
1	·5	8⅞	1780	1890
1	·6	9⅝	1835	1940
1	·7	10¼	1885	1980
1	·8	11	1953	2020

24 Pr. Howitzer. S. filled 21 lb. 4 oz. S. empty 11 lb. 1 oz. No. of Balls . . 129

Letter & Length of Fuze.		Elevation.	Range.
in.	10ths.	deg.	yds.
	·1	1	450
	·1½	1¼	500
B	·2	1½	550
	·2½	1¾	600
C	·3	2	650
	·3½	2¼	700
D	·4	2½	750
	·4½	2¾	800
E	·5	3	850
	·5½	3¼	900
	·6	3½	950
	·6½	3¾	1000
	·7	4	1050
	·7½	4¼	1100
	·8	4½	1125
	·8½	4¾	1150
	·9	5	1175
	·9½	5½	1200

12 Pr. Howitzer. S. filled 10 lb. 13¼ oz. S. empty 5 lb. 10 oz. No. of Balls . . 63

Letter & Length of Fuze.		Elevation.	Range.
in.	10ths.	deg.	yds.
	·1	1¼	450
	·1½	1½	500
B	2	1¾	550
	·2½	2	600
C	·3	2¼	650
	·3½	2½	700
D	·4	2¾	750
	·4½	3	800
E	·5	3¼	850
	·5½	3½	900
	·6	3¾	950
	·6½	4	1000
	·7	4¼	1025
	·7½	4½	1050
	·7¾	4¾	1075
	·8	5	1100
	·8¼	5¼	1125
	·8½	5½	1150
	·8¾	5¾	1175
	·9	6	1200

Ricochet Practice with Brass Ordnance.

Range in yards.	Solid Shot.				Common Shells.									
	12 Pr. Gun.		9 Pr. Gun.		24 Pr. Howitzer. Shell, 16lb.		12 Pr. Howitzer. Shell, 8lb.		5½ in. Howitzer heavy. Shell, 16lb.		5½ in. Mortar. Shell, 16 lb.		4⅖ in. Mortar. Shell, 8lb.	
	Charge.	Elevation.	Charge.	Elevation.	Charge.	Elevation.	Charge.	Elevation.	Charge.	Elevation.	Charge.	Elevation.	Charge.	Elevation.
	oz.	deg.	oz.	deg.	lb. oz.	deg.	oz.	deg.	lb. oz.	deg.	oz.	deg.	oz.	deg.
					6	7½								
400					9	4¾			12	5	8	14½	5	14½
			8	4					8	8				
	6	6½	7	5	8	9			12	7				
	5	7	6	6¼	10	7½								
			5	6¾	11	6			10	9				
500					12	5¼			8	11				
					14	5								
			7	6½	9	7¾	6	7						
600			6	7½	12	6½	8	6	1	6¾				
			5	9½	1	4¾	10	5	12	9				

NOTE.—When Shot are fired from the 24 Pounder, and 12 Pounder Howitzers, the Elevation must be about half a degree more than when Shells are used.

Range, Charge, Elevation, &c., of Iron Ordnance.

Nature.		Weight.	Length.		Diameter of the bore.	*Charge of powder.		Range in yards.						
								Point blank.	1°	2°	3°	4°	5°	6°
		cwt.	ft.	in.	in.	lb.	oz.							
GUNS.	42 Pr.	85	10		9·60	14		400	940	1340	1620	1840	2050	2250
	32 Pr.	63	9	7	6·41	10	10½	380	760	1130	1455	1730	1950	2160
		56	9	6	6·41	10	10½	380	760	1130	1455	1730	1950	2160
		48	8		6·41	8		330	680	1015	1300	1540	1740	1840
		40	7	6	6·35	6		340	675	985	1260	1500	1700	1800
	*	32	6	6	6· 3	5		330	670	945	1210	1450	1640	1730
	*	25	6		6· 3	4		225	485	735	995	1260	1500	1630
		25	5	4	6· 3	4		225	485	735	995	1260	1500	1630
	24 Pr.	50	9	6	5·82	8		360	755	1125	1417	1670	1850	2000
		48	9		5·82	8		360	755	1125	1417	1670	1850	2000
		40	7	6	5·82	8		340	730	1080	1377	1620	1800	1950
		33	6	6	5·82	6		260	530	805	1082	1350	1560	1760
	18 Pr.	42	9		5·29	6		360	730	1080	1377	1600	1780	1960
		38	8		5·29	6		340	710	1075	1347	1560	1730	1900
	12 Pr.	34	9		4·62	4		360	720	1075	1337	1540	1700	1850
		29	7	6	4·62	4		340	710	1040	1307	1500	1650	1800
	9 Pr.	26	7	6	4· 2	3		330	685	1015	1278	1460	1600	1730
	6 Pr.	17	6		3·66	2		320	655	985	1238	1400	1520	1610
CARRONADES.	68 Pr.	36	5	4	8·05	5	10½	270	540	812	1042	1240	1420	1570
	42	22	4	6	6·84	3	8	240	515	810	983	1180	1350	1880
	32	17	4		6·25	2	10	235	485	705	905	1100	1260	1400
	24	13	3	9	5·68	2		225	435	650	826	1000	1150	1300
	18	10	3	4	5·16	1	8	220	430	620	787	950	1100	1250
	12	6	2	8	4·52	1		205	375	580	738	880	1000	1100

* Bored-up guns.

Range, &c., of Iron Ordnance.

SHRAPNEL SHELLS.

68 Pr. Carronade.		8 in. Howitzer.		24 Pr. Gun.		18 Pr. Gun.		
lb. oz. Charge . . 4 0 Shell filled . 61 4 ,, empty 32 2 No. of Balls 337		lb. oz. Charge . . 4 0 Shell filled . 61 13 ,, empty 32 2 No. of Balls 337		lb. oz. Charge . . 5 0 Shell filled . 21 5 ,, empty 11 0 No. of Balls 128		lb. oz. Charge . . 4 8 Shell filled . 15 11 ,, empty 8 6 No. of Balls 90		
Elevation.	Fuse.	Elevation.	Fuse.	Elevation.	Fuse.	Elevation.	Fuse.	Range.
degrees.	tenths.	degrees.	tenths.	degrees.	tenths.	degrees.	tenths.	yards.
2½	4	2¾	3½	1¼	2	1¼	2	650
3½	6	3	6	1¾	3½	2	4	900
5	8½	6	10	2½	5	3	5¾	1100

Range, Elevation, &c., of 12, 10, *and* 8 *inch Guns*, 32 *Pr. Carronade Gun, and* 10, *and* 8 *inch Iron Howitzers.*

Nature of Ordnance.	Length.		Weight.		Charge.		Elevation in degrees; Range in yards; Flight in seconds.															
							Point blank.	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°
	feet.	in.	cwt.	qrs.	lb.	oz.																
12-in. Gun (Hollow Shot)	3	4	90	3	12		240	540	790	1020	1250	1400	1550									
10 Do. . . . . (H. S.)	7	6	57	3	7		210	460	720	935	1160	1350	1500									
	8	4	62	1	8		250	570	810	1030	1230	1400										
	9	4	84		12		325	630	930	1200	1460	1700										
8 Do. . . . . (H. S.)	6	8½	50		7		210	320	570	830	1130	1300										
8 Do. . (Solid Shot)	8	6	60		9	7	340	640	960	1190	1300	1500										
8 Do.	9		65		10		300	580	940	1220	1480	1700	1880	2120	2290	2430	2510	2710	2930	2990	3140	3250
Time of Flight . .							¾"	2"	3"	4½"	5½"	7"	8"	8¾"	9¾"	10¼"	11½"	12½"	12¾"	13"	13¼"	14"
Ditto. (Hollow shot)	9		65		12		370	700	1050	1230	1540	1700	1831	1980	2090	2310	2400	2510	2720	2830	2870	2220
Time of Flight . .							1"	2½"	3"	4½"	6"	6½"	7½"	8"	8¾'t	10"	10½"	11½"	12½"	13½"	14"	15½"
32 Pounder Carronade Gun	5		25		4		200	470	730	960												
10 inch iron Howitzer . .	5		40		7				600			1200	1320		1500		1926		2078			
8 inch Ditto	4		21		4				450	730			975		1227		1505		1725			

The above Ranges for the 12, and 10 inch Guns are with hollow shot, weighing respectively 112 lb., and 84 lb. The 8 inch Gun carries either hollow shot, plugged, 48 lb.; or shell, 46 lb.

56 *Pounder Gun, and* 68 *Pounder Gun.*

Weight, Ranges, &c.

	Gun.	Shot.	Charge.	P B	1°	2°	3°	4°	5°	6°	8°	10°	12°	Above Plane.	
	cwt.	lb.	lb.	yds.	yds.	yds.	yds.	yds.	yds.	yds.	yds.	yds.	yds.	feet	in.
56 Pr.	98	S S	16	490	930	1340	1720	2000	2200	2400	2740	3040	3320	5	
	87	S S	14	380	900	1310	1660	1940	2100	2310	2580	2940	3270	8	
68 Pr.	112	S S	20	400	980	1400	1760	1980	2240	2480	2840	3130	3400	8	
	95	S S	15	310	700	1070	1430	1710	1930	2130	2520	2890	3180	5	4
	95	Shell	16	350	850	1250	1560	1840	2100	2350	2690	3000	3300	5	4
	87	S S	14	300	680	1050	1360	1650	1900	2140	2490	2820	3150	8	
	87	Shell	14	310	710	1080	1350	1610	1850	2080	2450	2800	3140	8	

8 *Inch Gun.*

Length, 9 feet ; Weight, 65 cwt. ; Height of gun above the plane, 5 feet 7 inches.

Nature of shot.	Charge.	Elevation.	First graze.	Flight.	Second graze.	Extreme range.	Time of flight.	Number of grazes.
	lb.	Degrees.	Yards.	Sec.	Yards.	Yards.	Sec.	
Solid	10	P. B.	315	1″	901	3207	20″	23
	10	1°	660	2″	1006	2803	19″	18
	10	1½°	818	3″	1240	2433	16″	13
	9	P. B.	343	1″	776	2683	17″	12
	9	1°	615	2″	970	2483	15″	10

LONG RANGES.

Nature of Ordnance.	Weight.	Charge.	Shot, or shell.	Elevation.	Greatest range.
	cwt.	lb.		degrees.	yards.
68 Pr.	95	12	Eccentric hollow 8 inch shot.	24	6500
10 inch.	112	15	Eccentric shot, 91 lb.	28	5735
68 Pr.	95	16	Common shell.	27¼	5605

RICOCHET FIRING.

1. When adopted in the field, the guns should seldom be elevated above 3 degrees, as the objects fired at are generally cavalry, and infantry, and the lower the angle the longer will the shot preserve its force, and have effect.

2. In the ricochet of a fortification of any kind, the elevation should seldom exceed 10 degrees to throw the shot over the parapet a little higher than the level of the battery; and, on the whole, the best elevation to enfilade a work is from 6 to 9 degrees, measured above the crest of the parapet with corresponding charges.

3. The charge, and elevation being known for any range, when the gun, and parapet are on the same level, the same charge, and elevation may be used so long as the difference of level does not exceed one-twentieth of the horizontal distance between them, the elevation being given by the tangent scale, and the gun laid at the parapet, whether above, or below its own level.

Ricochet Practice with Iron Ordnance.

Range in yards.	Round Shot.								Common Shell.					
	68 Pr. Carronade.*		24 Pr. Gun, 9 Feet.		18 Pr. Gun, 8 Feet.		12 Pr. Gun, 8½ Feet.		10-inch Howitzer, Shell, 92 lb.		8-inch Howitzer, Shell, 46 lb.		24 Pr. Howitzer, Shell, 16 lb.	
	Charge.	Elevation.	Charge.	Elevation.	Charge.	Elevation.	Charge.	Elevation.	Charge.	Elevation.	Charge.	Elevation.	Charge.	Elevation.
	lb. oz.	deg.	lb. oz.	deg.	lb. oz.	deg.	lb. oz.	deg.	lb. oz.	deg.	lb. oz.	deg.	lb. oz.	deg.
400			12	6¼	9	6½	8	4¾	2 8	6¼	1 8	6	9	4¾
			10	7¾			6	6¼	2	8½	1	9½	6	7½
			8	11										
600	1 12	7	6	6	1	5½	12	4¾	3	6½	1 8	8½	1	4¾
	1 8	8½	1 8	4	12	7	10	6	2 8	8¾	1 4	10	12	5½
			1	6½			8	7¾					9	7½
800			2	3¾	1 8	4½	1	4½	4	6¼	2 8	6¼		
			1 8	5½	1	7	12	6½	3 8	7½	2	6¼		

* NOTE.—When Shells are fired from the 68 Pounder Carronade, the Elevation must be decreased about half a degree.

MORTARS.

Practical rules.

To find the Charge for a given Range at 45° elevation.

13-*inch Mortar.*—To the range, in yards, add half the range, multiply the sum by ·03 for the charge, in ounces.

10 *inch Mortar.*—When the range is under 1350 yards, add to the range 160, and multiply by ·02; and if the range is over 1350 yards, add one-fifth of the range, and multiply by ·02 for the charge, in ounces.

8 *inch Mortar.*—To the range, in yards, add 20, and the sum multiplied by ·015 will give the charge, in ounces.

5½ *inch Mortar.*—To the range in yards, add 150, and multiply by ·08, for the charge, in ounces.

4⅖ *inch Mortar.*—To the range in yards, add 300, and multiply by ·06 for the charge, in drams.

To find the time of flight, the range being given. Divide the square root of the range, in feet, by 4·5 for the time of flight, in seconds.

To find the Range, the Time of flight being given. Multiply the time of flight, in seconds, by 4·5, and square the product for the range, in feet.

*To find the length of Fuze,** for a given range. Multiply the time of flight, in seconds, by ·22, for the 13, and 10 inch mortars, and by ·24 for 8, 5½, and 4⅖ inch mortars, for the length of fuze, in tenths.

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* Old pattern.

Mortar Practice at 15°, 25°, and 45° Elevation. 1838.

13 INCH, IRON.

Weight . . . 36 cwt.
*Shell filled . . 200 lb.
Burst. powder 6 lb. 12 oz.
Blowing powder 2 oz.

Elevation.	Charge.		Fuze.	Range.
degs.	lb.	oz.	in.	yds.
45	2	1½	1·9	450
	2	3	2·	500
	2	4¾	2·1	550
	2	6	2·2	600
	2	7¾	2·3	650
	2	9½	2·4	700
	2	11¾	2·45	750
	2	14	2·5	800
	3	½	2·55	850
	3	3	2·6	900
	3	5½	2·65	950
	3	8	2·7	1000
	3	10	2·75	1050
	3	12	2·8	1100
	3	14	2·85	1150
	4		2·9	1200
	4	5	3·	1300
	4	15	3·2	1500
	5	10	3·4	1700
†	9			2900

10 INCH, IRON.

Weight . 16 cwt. 2 qrs.
Shell filled . . 92 lb.
Burst. powder 2 lb. 10 oz.
Blowing powder 1¼ oz.

Elevation.	Charge.		Fuze.	Range.
degs.	lb.	oz.	in.	yds.
45	1	½	1·9	450
	1	2	2·	500
	1	3¼	2·1	550
	1	4¾	2·2	600
	1	6	2·3	650
	1	7½	2·4	700
	1	9	2·45	750
	1	10	2·5	800
	1	11	2·55	850
	1	12	2·6	900
	1	13	2·65	950
	1	14	2·7	1000
	1	15¼	2·75	1050
	2	½	2·8	1100
	2	1¾	2·85	1150
	2	3	2·9	1200
†	4			2400

8 INCH, IRON.

Weight . . 8 cwt. 1 qr.
Shell filled . . . 46 lb.
Burst. powder 1 lb. 14 oz.
Blowing powder . 1 oz.

Elevation.	Charge.		Fuze.	Range.
degs.	lb.	oz.	in.	yds.
15		14	·8	500
	1		1·	550
	1	2	1·1	600
45		9½	1·9	450
		10¾	2·	500
		12½	2·1	550
		13¾	2·2	600
		14½	2·3	650
		15½	2·4	700
	1		2·45	750
	1	½	2·5	800
	1	1¼	2·55	850
	1	2	2·6	900
	1	2¾	2·65	950
	1	3½	2·7	1000
	1	4	2·75	1050
	1	4¾	2·8	1100
	1	5¼	2·85	1150
	1	6	2·9	1200
†	2			2000

5½ INCH, BRASS.

Weight 1 cwt. 1 qr. 10 lb.
Shell filled . . 16 lb
Burst. powder . 10 oz.
Blowing powder ¼ oz.

Elevation.	Charge.		Fuze.	Range.
degs.	oz.	drs.	in.	yds.
15	6		·7	350
	7		·75	400
	7	8	·8	450
	8		·85	500
25	5	8	1·1	480
45	4	8		300
	4	12		350
	5		1·75	400
	5	4	1·8	450
	5	8	1·85	500
	5	12	1·9	550
	6		1·95	600

4⅖ INCH, BRASS.

Weight 3 qrs. 19 lb.
Shell filled. . 8 lb.
Burst. powder 5 oz.
Blowing powder ¼ oz.

Elevation.	Charge.		Fuze.	Range.
degs.	oz.	drs.	in.	yds.
15	4	8	·8	450
	4	12	·85	500
25	4		1·1	540
45	2	6	1·65	300
	2	9	1·7	350
	2	12	1·75	400
	3		1·8	450
	3	4	1·85	500
	3	8	1·9	550
	3	12	1·95	600

* The Shells were filled with sand.

† Extreme ranges.

PART V.

STORES, IMPLEMENTS, COMBUSTIBLES, ETC., REQUIRED IN BATTERIES.

BALLS, LIGHT.

LIGHT Balls are thrown from mortars at night, to discover the operations of the enemy's working parties, &c.

Light balls burn from 10 to 20 minutes.

Composition.

	lb.	oz.		lb.	oz.
Saltpetre, pulverized . .	6	4	Rosin, pounded . . .	1	14
Sulphur, ground . . .	2	8	Linseed oil, boiled . .	0	7½

BALLS, SMOKE.

Smoke balls are fired from mortars to suffocate the men in mines, &c., or to prevent them continuing their work. They are also used to conceal manœuvres, &c., from an enemy.

Smoke balls burn from 25 to 30 minutes.

Composition.

	lb.	oz.		lb.	oz.
Corned mealed powder .	5	0	Swedish pitch	2	0
Saltpetre, pulverized . .	1	0	Tallow	0	8
Sea coal	1	8			

To construct hollow Globes, or Cases for Light balls, &c.

The canvas, or paper, may be formed in the following manner, viz.:—With radius of half the intended calibre, describe the circle A B C D (*vide Figure* 20, *Practical Geometry*), and divide the same into four equal parts. From B with radius A B describe arc A E, from A with radius A B describe arc B E, and from E with radius E A describe arc A B. Eight pieces, as E A B, will form a ball nearly spherical, the edges being brought close together.

CARCASSES.

Carcasses, a species of shell, are filled with composition, the flame from which is extremely powerful, and nearly unextinguishable. They are much used in bombardments of towns, setting fire to shipping, &c., and are discharged from guns, mortars, and howitzers, similarly to common shells; from which, however, they differ, in being made thicker, to enable them to withstand the intensity of fire, and in having three fuze holes instead of one.

Carcasses burn from 8 to 10 minutes.

All carcasses have three holes; and, from guns and howitzers, are fired with sabots.

Carcass Composition.

	lb.	oz.		lb.	oz.
Saltpetre, pulverized . .	6	4	Antimony, pounded . .	0	10
Sulphur, sublimated . .	2	8	Tallow.	0	10
Rosin, pounded . . .	1	14	Turpentine	0	10

Weight, and Dimensions of Carcasses.

Nature of Carcass. Land Service.	Exterior Diameter.	Weight, empty.		Weight, filled.	
	inches.	lb.	oz.	lb.	oz.
13 Inch.	12·84	220	0	234	8
10 Inch	9·84	97	0	104	0
8 Inch	7·86	52	4	57	0
5½ Inch	5·59	15	8	17	1
4⅖ Inch	4·45	8	4	9	1

CARTRIDGES FOR GUNS, HOWITZERS, ETC.

Nature of Ordnance.			Charge of Powder.		Dimensions of Patterns.		
					Length.	Circumference.	
						Top.	Bottom.
			lb.	oz.	inches.	inches.	inches.
Guns, Iron	68 Pounder		16		21½	23½	
	56 "		16		22	23½	
	" "		14		20	23½	
	" "		10		17	23½	
	" "		5		13	23½	
	42 "		12		20	21⅜	
	32 "		10		18	19⅝	
	24 "		8		17	18¼	
	18 "		6		18	17	
	12 "		4		16¼	14¾	
	9 "		3		14¼	13	
	6 "		2		13	11½	
	10 Inch		12		17½	15	12
	8 "		10		19	13½	10
Guns, Brass	12 Pounder	Medium	4		16¼	14¾	
		Light	3		14	14¾	
	9 "		2	8	12	12¾	
	6 "	Heavy	2		13	11½	
		Light	1	8	11	11½	
	3 "	Heavy	1		10	9	
		Light		12	8½	9	
Howitzers	Iron	10 Inch	7		13	15	12
		8 "	4		13	12	8
	Brass	32 Pounder	3		14	14¾	
		24 "	2	8	12	10	7
		12 "	1	4	12	8	6
		5½ Inch		8	7½	5¼	3⅝
		4⅔ "		4	6½	4¾	2¾
Carronades	68 Pounder		5	12	14½	22¾	
	42 "		3	5	12¾	19	
	32 "		2	10	12¼	18½	
	24 "		2		11½	16½	
	18 "		1	8	10	15¾	
	12 "		1		8¾	14½	
	9 "			12	7½	11½	
	6 "			8	7	10¼	

Cartridges for "Gomer" Chambered Guns are cut in two pieces, except for the 12 Pr. Howitzer.

FUZE (BOXER'S).

The wooden cases are made of well-seasoned beech. The composition bore is made excentric with regard to the exterior, and two powder channels are bored upon that side in which there is the greatest thickness of wood. A hole is bored through the mealed powder at the top, and into the fuze composition, to insure the ignition of the fuze composition from the priming. Two rows of holes (the holes two-tenths of an inch apart) are made into the powder channels, and the bottom hole in each row is continued to the axis of the composition bore. The small side holes, with the exception of the bottom ones, are filled with pressed powder, and a small portion of clay. The powder channels contain rifle powder, and the bottom side holes have a piece of quick match placed in them.

A simple boring bit is supplied to each gun, in case the borer, specially made for the fuze, is lost, or damaged.

Captain Boxer's 5½ inch fuzes are to be adopted for all natures of guns, and howitzers, one inch in length for Shrapnel shells, and two inches in length for common shells.

FUZE, NAVAL (BOXER'S).

Instructions for Naval Shells, and Fuzes.

All naval shells are now prepared so as to take a metal fuze with a *right-hand* screw 1·3 inch in diameter (outside measurement) and a pitch of 16½ threads to the inch: this arrangement has been made to enable all shells to be used either with the Moorsom, or the time fuze.*

The "bottoms" or "sabots" of all naval shells are hollowed out in order that the shot may be in contact with the metal of the shell when the gun is charged with shot, and shell.

All "bottoms" or "sabots" for 8 inch naval shells are tapered, and are suited either for the 68 pounder, or the 8 inch guns.

The top of Boxer's naval time fuze is assimilated to the Moorsom fuze, as regards the arrangement for screwing, and unscrewing.

In the Moorsom fuzes made previous to September, 1858, there are only two holes in the head of the fuze, and these holes are not so far apart as those in the Moorsom, and time fuzes at present manufactured. Two additional pins to correspond with the holes in head of the Moorsom fuze, made previously to the date of the order above quoted, are placed in the new spanners.

Four holes are now made in the heads of both the Moorsom, and Boxer's time fuzes, and these holes are also at the same distance apart in each.

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* The time fuzes made previous to September, 1858, cannot be used for the Moorsom shells at present in store—but only for the shells prepared especially for them before the above date.

There are two descriptions of time fuzes for the navy: the one is driven with mealed powder, and burns 7½ seconds, at the rate of ·1 inch in ¼ second: and the other is driven with fuze composition, and burns 20 seconds, at the rate of ·1 inch in ½ second.

The mealed powder fuze is marked with a red ring on the top of the cap, and with M. P. on the *side of the square,* and the holes are coloured red. The composition fuze has the holes painted white.

The fuzes are marked according to the time of burning, and not, as in the old pattern, *according to the length of composition.* Small holes, ·2 inch apart, are drilled completely through the metal, and the bore is lined with a cylinder of paper ·075 inch thick, which prevents the fire of the burning composition from issuing through the holes.

There are two rows of holes in each fuze: this arrangement is necessary in order to obtain the required sub-division—for, on account of the size of the holes, they cannot be made closer than ·2 inch, but by having two rows the sub-division is extended to ·1 inch.

A brace, and bit are supplied, to prepare the fuzes for service.

The mealed powder fuze should always be used when the time of flight is not required to be more than 7½ seconds.

To PREPARE BOXER'S NAVAL FUZE FOR SERVICE.—Hold the fuze firmly in the left hand—place the head of the brace next the body—insert the point of the bit into the hole which corresponds to the time required, and turn with the right hand till the stop comes in contact with the metal.

FUZE, MORTAR (BOXER'S).

Fuze for 13, 10, *and* 8 *inch Mortar Shells.*

The fuze for mortar shells has a spiral row of holes, the centres of which are ·2 of an inch apart in the direction of the axis of the fuze.

Directions for preparing the Fuze for any particular range.

Hold the fuze firmly in the left hand, insert the point of the bit into the required hole, place the head of the brace against the body, and turn with the right hand until the stop comes in contact with the wood.

N.B.—The wood bottom of the fuze must on no account be cut off, as it supports the composition, and prevents its being disarranged by the shock at the discharge.

Note.—The 13, and 10 inch shells at present in store have larger fuze holes than those which will be hereafter cast. Fuzes on a similar principle, but larger in diameter, will be supplied with these shells.

The fuze holes of the old shells being irregular in size and shape, the fuze must be rasped if necessary.

GREASE.

The composition used for greasing wheels is composed of equal parts of tallow, and coarse sweet oil melted together, and it is made up in kegs of 28 lb. each. In warm weather the proportion of tallow must be increased.

GRENADES, HAND.

A Land service Hand grenade weighs 1 lb. 13 oz., and may be thrown from 40 to 60 feet. The diameter of the fuze composition is ·2 of an inch, length 2·25 inches, and weight 3 drams.

Bursting charge, 1½ ounce.

GUNPOWDER.

The component parts of Powder are 75 parts of nitre, 10 of sulphur, and 15 of charcoal.

Cylinder powder is made from charcoal that has been burnt in iron cylinders; and *Pit powder* from charcoal burnt in common pits.

Gunpowder, when ignited, expands with a velocity of about 5,000 feet per second; and the pressure of the fluid is about 2,000 times that of common air.

One pound of Powder measures 32 solid inches.

A cubic foot of Government powder weighs about 58 pounds.

Gunpowder is manufactured by reducing the nitre, sulphur, and charcoal to powder; they are then mixed, moistened with water, and again mixed in a mill for five or six hours, or until the mixture is as intimate as possible, for upon this the strength of the powder chiefly depends.

When taken from the mill, the composition is put in a press, and formed into hard cakes about a quarter of an inch thick; these, when dry, or nearly so, are broken by wooden mallets into small pieces, and reduced into grains by being put into sieves, and forced by means of a wooden roller through circular holes of the proper diameter.

Good powder should be devoid of smell, and of uniform colour, approaching to that of a slate. The particles should be perfectly granulated, and free from cohesion. It should admit of being readily poured from one vessel to another.

In powder that has become damp, large lumps are formed: should the damage, however, not be very considerable, these concretions may be reduced by drying the powder in a hot-air stove, rubbing and loosening the grains; but powder thus affected never thoroughly regains its lost strength.

To test the purity of powder.—Lay a dram of it on a piece of clean writing-paper, and fire the heap by means of a red-hot iron wire: if the flame ascend quickly with a good report, leaving the paper free from white specks, and without burning holes in it, the goodness of the ingredients, and proper manufacture of the powder may be safely inferred.

Good powder blasted upon a clean plate of copper should leave no track, or mark of foulness.

Powder exposed for 17 or 18 days to the influence of the atmosphere ought not to increase materially in weight. One hundred pounds of powder should not absorb more than twelve ounces: if it increase in weight more than one per cent., the powder should be condemned.

Proof of Gunpowder.

To prove the strength of *large grain, or common powder*, 2 ounces are fired from 8-inch Gomer mortars (at an angle of 45°), placed on stone beds, and so fixed as not to recoil. These mortars are loaded with shot weighing 68 pounds, and the average of the ranges, with Government powder of Waltham Abbey, is 250 feet. Powder made of common pit charcoal will only project such a ball, under the same circumstances, about 220 feet; and powder that has been re-stoved will only produce a range of from 107 to 117 feet.

A musket, charged with two drams of *fine grained, or musket powder*, should drive a steel bullet through 15 or 16 half-inch elm boards, placed three-quarters of an inch from each other, the first board being set at 40 inches from the muzzle of the musket: with re-stoved powder, the bullet will only perforate from 9 to 12 of the boards.

The quality of large grain powder is ascertained by its general appearance, its firmness, glazing, uniformity of grain, and density.

POWDER MARKS.

The various sorts of Powder are distinguished by the following marks on the heads of the barrels:—

*L G	Large grain.
*F G	Fine grain.
R A	For rifle arms.
†L G	Large grain.
†F G	Fine grain.
R S	Re-stoved.

**Red* L G, or F G, denotes powder of the best quality. † *White* L G, or F G, is an inferior Powder for salutes, &c.

POWDER MAGAZINES.

To ascertain if a Magazine is damp.—Soak a piece of sponge in a solution of salt of tartar, or common salt and water: let it be well dried, and weighed, and then be placed in the magazine, which, if damp, will cause the sponge to become heavier.

A small weight, suspended by a piece of catgut, or hair, will also discover moisture, causing the former to contract, and the latter to lengthen.

POWDER BARRELS.

Whole Barrels contain 100 lb., and Half Barrels 50 lb., of powder, whether fine, or coarse.

Dimensions of Powder barrels.

	Whole barrels. inches.	Half barrels. inches.	Quarter barrels. inches.
Depth	20½	16¾	14
Diameter at top .	15¼	12¼	9½
Do. at bulge . .	16¾	13¼	10¼
Do. at bottom . .	15½	12¼	9½

BUDGE BARRELS.

Weight of barrel, copper-hooped, 10 lb., hazel-hooped, 6 lb.

Length of barrel	10½ inches	each barrel will contain 38 lb.
Diameter . .	13 ,,	

CASES, POWDER (BOXER'S).

Pentagonal.—*Dimensions of sides in inches.*

One—15·42. Two—11·044. Two—9·2. Depth of case—19·2. Weight, 68 lb.

HANDBARROWS.

Length, 5 ft. 3 in. Breadth, 2 ft. Weight, 19 lb.

HANDSPIKES.

Length, 5 ft. Diameter at top, 1·25; Diameter at bottom, 2·75 inches. Length of square, 1 foot 9 inches. Weight of ten, 64 lb.

There is a larger kind, 6 feet in length; weight of ten, 100 lb.

LEVERS.

	ft.	in.		lb.
Iron shod, length .	4	0	. . . Weight of 5 . .	36
Common	6	6	. . . Do. . .	54

LIGHTS, LONG (BOXER'S).

The paper case is 10 inches long, 6 inches of which are filled with composition; one end is left open to fix on a wooden holder; the other end is fitted with a nipple, on which a percussion cap is to be placed. By giving the cap a smart blow on some hard substance, it ignites the composition, which will burn for six minutes.

Composition.

	lb.	oz.
Saltpetre, ground	7	0
Sulphur, sublimated	1	12
Red orpiment	0	8

LIGHTS, SIGNAL (BOXER'S).

This is similar to the LIGHT, LONG, but has only one inch of composition.

MATCH, QUICK.

Composition.

	lb.	oz.		
Cotton wick . .	2	2	Gunpowder .	12 lb.
Gum arabic . .	0	8	Water . .	4 quarts.

Four pounds of the gunpowder are mixed into a thin paste with a portion of the gum-water *boiling*: in this the cotton is then immersed. Six pounds of gunpowder made into a stiff paste, with the remainder of the gum-water, is spread on the top of the match, which is afterwards reeled off, the remaining two pounds of powder being sifted on the match while on the reel, and some of the stiff paste being held in the hand through which the match passes.

MATCH, SLOW.

Slow match is prepared from slightly-twisted hemp rope, which is dipped in a solution of lime water, and saltpetre.

One yard burns about three hours. One skein, 35 yards, weighs seven pounds.

During the Siege of Gibraltar, Slow match was thus made:—Eight ounces of saltpetre were put in a gallon of water, and just made to boil over a slow fire, strong blue paper was then wetted with the liquor, and hung to dry. When dry, each sheet was divided into two parts, which were rolled up tight, and the outward edges pasted down. Each half sheet would burn three hours.

French slow match is made by soaking light twisted white rope in a solution of one pint of rain water, and three quarters of an ounce of sugar of lead.

PARACHUTE, LIGHT BALL (BOXER'S).

This light ball consists of a paper shell, enclosing two tin hemispheres, one containing the composition, the other the parachute. The shell is fired from a mortar, having a fuze, fixed in the usual manner, which communicates with the bursting powder, opens the shell, and lights the composition in the hemisphere attached to the parachute, which, suspended in the air, renders conspicuous the objects required to be illuminated.

Composition.

	lb.	oz.
Saltpetre, ground	7	0
Sulphur, sublimated	1	12
Red orpiment	0	8

PENDULUMS.

A Pendulum is readily made with a musket ball, and a piece of silk. The length of a Pendulum is measured from the centre of the ball to the end of the loop on which it swings.

Length of Pendulums to vibrate	Seconds . .	39·14 inches
	½ Seconds . .	9·8 „
	¼ Seconds . .	2·45 „

To find the length of a pendulum to make a given number of vibrations.

Rule.—As the square of the given number of vibrations is to the square of 60, so is the length of the standard (39·14, length for one second) to the length sought.

Or, multiply 39·14 by the square of the time required for the Pendulum to vibrate—viz., by the square of ½ = ¼, for ½ second; and by the square of 2 = 4 for two seconds.

To find the number of vibrations, the length of pendulum being given.

Rule.—Multiply 60 seconds by the square root of 39·14, divided by the length of the given pendulum.

Or say, As the given length is to the standard length, so is the square of 60 (its vibrations per minute) to the square of the number required.

PORTFIRES.

Portfires are of four different natures—viz., Common portfires, Percussion portfires, Miners' portfires, and Slow portfires.

A common portfire is 16 inches long, and will burn 13 minutes.

Composition.

	lb.
Brimstone, sublimed	2
Powder, cylinder mealed	1
Saltpetre, pulverized	6

PORTFIRES, PERCUSSION.

Composition.

Brimstone, sublimed	4
Powder, cylinder mealed	1
Saltpetre, pulverized	8

The percussion priming is added to these portfires at the stations where they are used (principally for the Coast Guard), and is simply a small glass globule, containing sulphuric acid. This is embedded in loose composition, which ignites on the globule being broken. A percussion portfire will burn 5 minutes.

PORTFIRES, MINERS'.

Composition.

	lb.	oz.
Saltpetre, pulverized	0	8
Sulphur, sublimed	0	8
Powder, cylinder mealed . . .	1	0

PORTFIRES, SLOW.

The paper, which is called blue sugar-loaf paper, is wetted by dissolving 12 ounces of saltpetre in one gallon of water, wetting each sheet separately on both sides with a brush, one side being dried before the other is made wet.

Slow portfires burn from three to four hours.

Portfires were made during the Siege of Gibraltar in the following manner: Two ounces of nitre were dissolved in a gallon of water, and sheets of soft brown paper dipped in the solution; these, when dry, were rolled up to about the size of common portfires.

Portfires may be made by boiling square rods of lime, birch, or poplar, in a solution of nitrate of lead for six hours (a quart of water to every pound of the nitrate); the matches are then dried, and afterwards boiled in spirits of turpentine; they are then wiped, and dried. A yard of this match will burn three hours.

PORTFIRES, COAST GUARD.

Composition.

Saltpetre 8 lb. Sulphur 4 lb. Cylinder mealed powder 1 lb.

QUOINS.

Nature.	Length. ft.	in.	Width. inches.	Thickness. inches.
42 Pr.	2	3	10·75	6·75
32 „	2	3	10·75	6·75
24 „	2	9	9·5	6·75
18 „	2	9	9·5	6·75
12 „	1	11	9·25	6·25
9 „	1	11	9·15	6·

ROCKETS.

There are two descriptions of Rockets:—

1st.—*Signal Rockets.* 2nd.—*Congreve Rockets.* (*Vide* PART VII.)

SIGNAL ROCKETS.

Signal rockets are of two natures—viz., 1 lb. and ½ lb. Rockets. They are fired from a tube, the ignition being effected by means of a percussion tube.

Composition.

	lb.
Saltpetre, pulverized	4
Sulphur, sublimed	1
Dog-wood charcoal	1½

Composition for Stars of Rockets.

	lb.		lb.
Saltpetre, pulverized . . .	8	Sulphur, sublimed . . .	2
Antimony, pounded . . .	2	Isinglass . . .	3 oz. 8 drs.
Cylinder mealed powder . .	1	Vinegar . . .	1 quart.
Spirits of Wine . .	1 pint.		

The head of a 1 lb. rocket contains 36 stars, and that of the ½ lb. rocket 24 stars.

SHELLS.

Shells are hollow iron Shot, and are of various descriptions, viz. :—

1st.—The *Common shell*, with one fuze hole, used in the attack, and defence of fortresses, &c., against shipping, and troops.

2nd.—The *Carcass*, which has three fuze holes, is filled with burning composition, and is used to set fire to towns, &c.

3rd.—The *Shrapnel shell*, which is very destructive when used against bodies of Cavalry, or Infantry, as it produces the same effect as common Case or Canister shot from guns, or howitzers, but at a much greater range.*

Diameter, and thickness of each Shell in the Service.

Nature of Shell.		Mean Diameter.	Mean Thickness.	Bursting Powder.		
		inches.	inches.	lb.	oz.	dr.
MORTAR	13 Inch . . .	12·84	2·146	10		
	10 " . . .	9·85	1·646	5	8	
	8 " . . .	7·86	1·39	2	4	
COMMON	10 Inch . . .	9·85	1·646	5	8	
	8 " and 68 Pr.	7·86	1·39	2	4	
	32 Pr.	6·177	1·034	1	0	
	24 " or 5½ Inch	5·595	0·936		13	
	18 "	5·099	0·803		10	
	12 " or 4⅔ Inch	4·454	0·746		6	
NAVAL	10 Inch . . .	9·85	1·35	5	8	
	8 " . . .	7·925	1·35	2	4	
	32 Pr. . . .	6·177	1·034	1	0	
IMPROVED SHRAPNEL	8 Inch . . .	7·86	0·82		4	3
	32 Pr. . . .	6·177	0·64		2	8
	24 " . . .	5·595	0·58		1	9½
	18 " . . .	5·099	0·53		1	8
	12 " . . .	4·454	0·447		1	0½
	9 " . . .	4·08	0·41			14
	6 " . . .	3·55	0·356			9½

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* *Vide* Practice Tables for Ranges, Elevations, &c.

All shells are now issued with a metal plug, fitted into the fuze hole.

SHOT, CASE OR CANISTER.

The common Case or Canister shot consists of a number of balls packed in tin canisters of a cylindrical form: the balls being of different weights according to the size of the gun. For field service the balls are counted into the case, and laid in tiers, but for other purposes they are loosely thrown in till the case is filled. The top being soldered on, the bottom of the tin case is nailed on to the wooden bottom, and the heads of the nails are soldered. These shot should seldom be used at a greater distance than 300 yards, and even at that range they scatter so much as to be nearly unserviceable; but at from 100 to 200 yards they are very destructive.

COMMON CASE, AND GRAPE SHOT.

	Nature of Ordnance.	Shot, Common Case, or Canister. Weight of Ball.		Number in the Case.	Weight of Case filled.		
		lb.	oz.		lb.	oz.	dr.
Iron Guns.	10 Inch*	1	 13⅛	34 50	86	6	4
	8 „ +		8	90	50	10	2
	68 Pr. +		8	90	50	14	2
	56 „ +	1		50	55	11	2
	42 „ +		8	85	46	12	2
	32 „ +		8	66	36	4	6
	24 „ +		8	46	25	7	2
	18 „ +		6½	41	19	4	10
	12 „ +		4	46	12	2	
	9 „ +		3	44	9	11	
	6 „ +		2	40	5	10	
	3 „ +		1½	34	3	9	8
Brass Guns.	12 Pr. +		6½	41	17	13	0
	9 „ +		5	41	13	13	8
	6 „ +		3½	41	9	2	8
	3 „ +		1½	41	4	5	0
Howitzers.	10 Inch +		8	170	85	6	0
	8 „ +		2	258	38	0	8
	5½ „ +		2	100	14	11	8
	4⅖ „ +		2	50	7	14	12
	32 Pr. +		3½	105	23	0	12
	24 „ L. S. +		2	140	14	1	8
	24 „ S. S. +		8	30	16	9	14
	12 „ L. S. +		2	84	7	4	12
	12 „ S. S. +		8 4	15 3	9	3	2
Carronades.	68 Pr. +		8	90	49	8	
	42 „ +		8	66	35	9	
	32 „ +		8	40	21	15	
	24 „ +		8	32	17	10	
	18 „ +		6	31	12	13	
	12 „ +		4	32	8	14	
	9 „ +		3	30	6	5	8
	6 „ +		2	30	4	5	8

	Nature of Ordnance.	Shot, Grape. Weight of Ball.		Number in the Case.	Weight of Grape Shot.		
		lb.	oz.		lb.	oz.	dr.
Guns. Caffin's Grape.	10 Inch*	3		24	81		
	68 Pr. & 8 Inch	3		15	50	7	
	56 Pr.	4		12	56	14	
	42 „	4		9	41	6	
	32 „	3		9	29	11	
	24 „	2		9	20	10	
	18 „	1	8	9	16	12	
	12 „	1		9	11	2	
	9 „		13⅛	9	8	12	
	6 „		8	9	8	7	
	3 „		4	9	2	9	
Carronades. × In Tin Case.	68 Pr.	3		15	55	10	
	42 „	4		9	42	8	
	32 „	3		9	32	8	
	24 „	2		9	22		
	18 „	1	8	9	16	8	
	12 „	1		9	11	4	
	9 „		13⅛	9	8	14	2
	6 „		8	9	5	11	0

* Sheet iron cylinder with wrought-iron plate top, and bottom.

+ Wood Tampeon.

× Grape for Carronades are packed in tin cylinders, fitted with plate-iron tops, and wood Tampeons.

STOOL BEDS.

NATURE.	BEDS.			BLOCKS.			
	Length. ft.	Breadth. in.	Thickness. in.	Length. ft.	in.	Breadth. in.	Depth. in.
42 Pr.	2·91	11	4·5	1	5	4·75	9
32 „	2·91	10	4·25	1	5	4·75	9
24 „	2·83	10	4·25	1	4	4·5	8
18 „	2·85	9·5	4·25	1	3	4·5	8
12 „	2·85	9·5	4	1	3	4·5	8
9 „	2·85	9·5	4	1	1	4·5	8

TUBES.

Tubes are of five different natures—viz., Common quill, and Dutch or Paper tubes for exercise, and Detonating quill, and Brass tubes; and Friction tubes for service.

The pipes for the *Quill tubes* are 2½ inches long; and the barrels of *Dutch tubes* are 1¾ inch in length. *Brass tubes, common*, are 3 inches long.

All tubes are gauged to two-tenths of an inch diameter.

Composition for Common tubes.

Mealed powder, mixed with spirits of wine into a stiff paste.

DETONATING TUBES.

The quills of these tubes are cut to 2¾ inches in length. Small, or pigeon quills, are also prepared for the arms to receive the detonating composition; these are cut to ¾ of an inch in length; and a small hole is bored in the centre to communicate the composition to the body of the tube.

Composition for the Crosses, or Arms, of Detonating tubes.

Chlorate of potassa	230 grains.
Antimony	230 „
Glass, finely pounded . . .	73 „

FRICTION TUBES.

These tubes are of copper, and are three inches in length. The detonating composition is inserted in a tin arm, into which is introduced and pressed down tight, by the sides of the arm, a piece of copper, grooved; with a small ring to receive the cord for firing the tube, and gun.

WADMILTILT.

Length, 14 ft. 6 in. Breadth, 11 ft. 6 in. Weight, 50 lb.

WOODEN BOTTOMS, OR SABOTS.

They are riveted to shot for brass guns, to prevent the bore being indented in front of the shot by the first impulse of the powder: and to Shells, to keep the fuze in the centre of the bore.

PART VI.

CARBINE EXERCISE,

for the Royal Regiment of Artillery.

MANUAL EXERCISE.

* "Attention. Present arms—Two—Three. Advance arms—Two. Order arms—Two—Three. Advance arms—Two. Support arms. Stand at ease. Attention. Advance arms—Two. Trail arms—Two. Advance arms—Two. Order arms—Two—Three. Stand at ease."

To fix, and unfix Swords.

* "Attention. Fix swords. Advance arms—Two. Charge swords. Advance arms—Two. Order arms—Two—Three. Unfix swords. Stand at ease."

THE PLATOON EXERCISE,

AND DIFFERENT FIRINGS FOR THE RIFLE CARBINE.

To load, and fire Standing, and Kneeling.

* "Platoon exercise by motions. *From Advanced Arms.* Prepare to load—*Standing.* (*Kneeling*—Two.) Load—Two—Three—Four—Five. Rod—Two. Home—Two—Three—Four. Return—Two. Cap—Two—Three—Four—Five—Six."

* "At —— yards, Ready. *From the Capping position* (*Standing*—) (*Kneeling*, Two.) *From Advanced arms* (*Standing*—Two.) (*Kneeling*—Two—Three.) Present — Two — Three — Four—Five. Load."

FROM THE CAPPING POSITION.

Standing. Kneeling.

* "Advance arms—Two. Order arms."

REVIEW EXERCISE.

* "Platoon exercise in Slow time.

Prepare to load, *in* 2 *motions.* Load, *in* 5 *motions.* Rod, *in* 2 *motions.* Home, *in* 4 *motions.* Return, *in* 2 *motions.* Cap, *in* 6 *motions.* Fire a volley, at —— yards, Ready, *in* 1 *motion.* Present, *in* 5 *motions.*"

"In Quick time. Load. Advance arms.

Company (Right wing, or Battalion) Fire a volley. At —— yards, Ready. Present.——Cease firing. Half-cock arms."

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* *Words of command,* Roman. *Instructions, &c., Italics.*

When a Company, Column, or Line is required to load.
* "With cartridge, (or As with cartridge) Load, &c."

INDEPENDENT, OR FILE FIRING.

* "File firing from the Right (or Left, or from both flanks) of Companies. Commence firing. Cease firing."

EXERCISE TO RECEIVE CAVALRY.

* "Prepare to resist Cavalry. Ready. Commence firing from the Right (or Left, or from both flanks) of Faces. Cease firing. Kneeling ranks (or front Face, *as the case may require*). Fire a volley. At —— yards, Ready. Present. Load."

MODE OF INSPECTING A COMPANY.

* "Double distance, Rear rank take open order. March. Port arms. Half cock arms. Ease springs. Examine arms. Advance arms. *The inspection of appointments, clothing, &c., next takes place.* Rear rank take close order. March. Support arms. Stand at ease."

SLINGING ARMS.

* "Prepare to sling to the Right. Sling—Two. Advance arms—Two. Prepare to sling to the Left. Sling—Two. Advance arms—Two.

TO FIRE A FEU-DE-JOIE.

* "With Blank cartridge, Load. Present — Present — Present. Present arms. Advance arms. *Three cheers.*"

FUNERAL EXERCISE.

The firing party is drawn up two deep, with open ranks, facing the place where the Corpse is lodged: and, when it is brought out, the officer commanding will give the words—

* "Present arms. Reverse arms. Rear rank take close order. March."

At the burial ground; "Rest on your arms Reversed. Stand at ease." *The Corpse having passed through;* "Reverse arms." *The ranks are closed, and the Firing party move to the grave, where they take up their position at Open order.* "Rest on your arms Reversed. Stand at ease. Attention. Present arms. Advance arms. Load." *Three volleys are fired in the air; after the third volley, half cock arms, take off the old cap, and ease springs. Advance arms, and return to quarters, right in front, in quick time.*

FIELD BATTERY EXERCISE.*

STANDING DRILL.

Section 1. *Telling off the Detachments.*†

Section 2. *Posts of the Detachment.*

Art. 1.—*In Action.*

No. 1. At the handspike.

Nos. 2, 3. Outside the wheels: with Howitzers rather in rear of the muzzle; with Guns in line with the front of the wheels.

Nos. 4, 5. In line with the breech.

No. 6. Five yards in rear of the left wheel.

No. 7. In rear of the Limber.

No. 8. Ten yards in rear of No. 6.

No. 9. Four yards in rear of the Limber.

Art. 2.—*In Order of March.*

No. 1. On the off side at the wheel horses' heads.

Nos. 2, 3. In line with the muzzle.

Nos. 4, 5. In line with the breech.

Nos. 6, 7. In line with the axletree of the Limber.

Nos. 8, 9. In line with the splinter bar.

Art. 3.—*In Front.*

In line, ten yards in front of the leading horses.

Art. 4.—*In Rear.*

In line, two yards in rear of the muzzle of the Gun.

Art. 5.—In line with the gun axletree, one yard to the right, or left of the wheel.

Art. 6.—*Mounted.*

No. 1. On the right. No. 6. On the left.	On the Gun limber.
No. 5. On the right. No. 4. On the left.	On the Waggon limber.

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* Extracted from "Instructions and Regulations for Field Battery Exercise and Movements" for the Royal Regiment of Artillery: the Sections, &c., being similarly numbered.

Commander's Words are printed in . .	SMALL CAPITALS.
Executive	Common type.
Directions, &c.	*Italics.*

† The Sections, of which merely the heads are given, consist chiefly of details too long for the limited size of the Manual, and they are therefore necessarily omitted.

No. 3. On the right. No. 2. On the left.	On the front of the Waggon body.
No. 7. On the right. No. 8. On the left.	On the rear of the Waggon body.

When there are 9 men, No. 9 between Nos. 5, and 4.

Section 3. *Change of Position of Detachments.*

1. FORM THE ORDER OF MARCH.	*Nos.* 1. Right face. Double march.
2. FORM THE ORDER OF MARCH.	*Nos.* 1. Left face. Double march.
3. DETACHMENTS REAR.	*Nos.* 1. Right about face. Double march. Halt. Front.
4. DETACHMENTS FRONT.	*Nos.* 1. Double march. Halt.
5. DETACHMENTS RIGHT.	*Nos.* 1. Right (or left) face. Double march. Front turn. Halt.
6. DETACHMENTS REAR.	*Nos.* 1. Right about face. Double march. Halt, front.
7. DETACHMENTS FRONT.	*Nos.* 1. Double march. Halt. Front.

Section 4. *Detail of Duties in the service of Ordnance.*

No. 1 Commands, and lays the Gun.
No. 2 Sponges.
No. 3 Loads, and serves ammunition.
No. 4 Serves the vent, and primes. After the discharge he clears the vent with the drift, previous to reloading.
No. 5 Fires.*
No. 6 Serves ammunition.
No. 7 Attends the Limber, and serves ammunition to No. 8.
No. 8 Assists No. 7.
No. 9 Attends the ammunition Waggon.

CHANGING ROUND.

No. 2	becomes	No. 4.	No. 8	becomes	No. 6.
No. 4	,,	No. 9.	No. 6	,,	No. 1.
			No. 1	,,	No. 5.
No. 9	,,	No. 7.	No. 5	,,	No. 3.
No. 7	,,	No. 8.	No. 3	,,	No. 2.

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* When Guns are in action, and "CEASE FIRING" is given, all Guns then loaded are to be fired off, and on no account is a Gun to be limbered up, or to move whilst loaded.

Exercise, with Reduced Numbers.

Nos. Retained.	Distribution of duties.							
	1	2	3	4	5	6	7	8
1, 2	1, 4, 5,	2, 3, 6						
1, 2, 3	4, 5,	2	3, 6					
1, 2, 3, 4. . . .	1	2	3, 6	4, 5				
1, 2, 3, 4, 5 . . .	1	2	3, 6	4	5			
1, 2, 3, 4, 5, 6 . .	1	2	3	4	5	6		
1, 2, 3, 4, 5, 6, 7 .	1	2	3	4	5	6	7	
1, 2, 3, 4, 5, 6, 7, 8 .	1	2	3	4	5	6	7	8

DISTANCES REQUIRED,

for a Field battery of Six guns.

	4 horses to each carriage—	6 horses to each gun. 4 „ to each waggon.
In Line, from muzzle to muzzle .	15 yards	19
In Column of Route	177 „	200
„ Sub-divisions . .	87 „	110
„ Divisions . . .	87 „	106
„ Half-battery . .	72 „	83

A Gun, or Waggon, with 4 Horses covers 11 yards of ground, from front to rear.

For every additional pair of Horses 4 yards should be added.

A Battery of 6 Guns, when limbered up at full intervals, without spare carriages, occupies from

Right to left . . . 95 yards | Front to rear. . . 34 yards.

On each flank, 22 additional yards should be allowed.

A battery of 6 Guns, when unlimbered for Action, at full intervals, occupies from

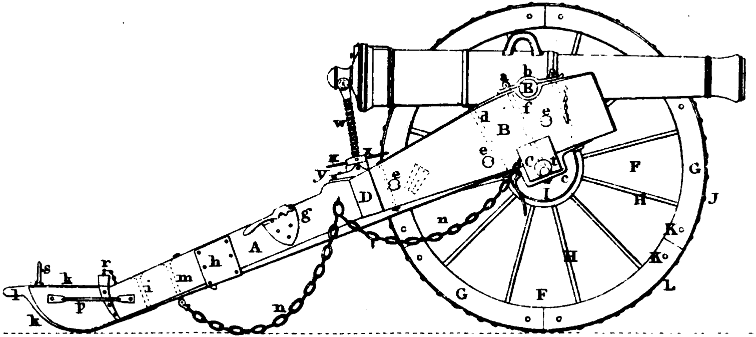
Right to left . . . 95 yards | Front to rear. . . 45 yards.

The space required for reversing a Gun with 6 horses is 12 yards, and for a Waggon about 8 yards.

NAMES OF THE PRINCIPAL PARTS OF A FIELD GUN CARRIAGE.

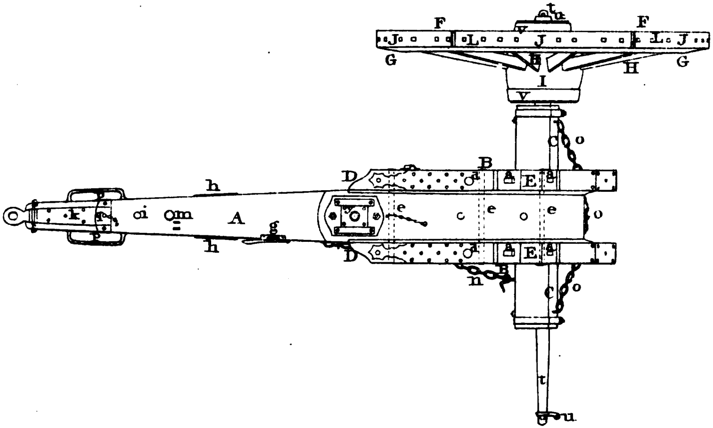
A Block, or Trail.
B Cheeks, or Brackets.
C Axletree.
D Ogee.
E Trunnion holes.
F Wheel.
G Felly.
H Spokes.
I Nave.
J Tire, or Streak.
K Rivets.
L Tire, or Streak bolts.

ELEVATION OF A 9 Pr. BRASS FIELD CARRIAGE.



PLAN OF A 9 P^{R} BRASS FIELD CARRIAGE.

1.



a Eye, or Capsquare bolts.
b Capsquares.
c Axletree bands.
d Bracket bolts.
e Transom bolts.
f Trunnion plates.
g Portfire clipper.
h Locking plate.
i Trail plate bolt.
k Trail plate.
l Trail plate eye.
m Chain eye bolt.
n Locking chain.
o Breast, or advancing chain.
p Trail handles.
q Handspike shoe.
r Handspike pin.
s Handspike ring.
t Axletree arms.
u Dragwashers.
v Nave hoops.
w Elevating screw.
x Handles of elevating screw.
y Elevating screw box.

Section 5. *Method of performing the duties of serving ordnance.*
Section 6. *Ranges.*
Section 7. *Method of laying a piece of ordnance.*
Section 8. *Limbering up.*

FRONT (REAR, RIGHT, OR LEFT) LIMBER UP.	Halt: Limber up.

Section 9. *Unlimbering, or coming into action.*
To the front, rear, right or left. *The reverse of limbering up.*
Section 10. *Moving with the Prolonge.*

PREPARE TO RETREAT WITH THE PROLONGE.	*Nos.* 1
THE BATTERY WILL RETIRE.	Right about face.
HALT.	
UNHOOK PROLONGE.	Front.

PREPARE TO ADVANCE WITH THE PROLONGE.	*Nos.* 3
ACTION.	Drive on.

Section 11. *Mounting field ordnance,* with the materials belonging to the battery.

Section 12. *Dismounting field ordnance,* with the materials belonging to the battery.

Section 13. *Shifting shafts.*

Section 14. *Disengaging a shaft horse,* when he falls, or is disabled in action.

Section 15. *Changing wheels,* when the lifting jack is not at hand.

Section 16. *Shifting the medium* 12 *pounder.*

Section 17. *To remove disabled field artillery.*

Section 18. *Exercise with Drag-ropes.*

1. A light 6 pounder with its limber requires 15 men, six of whom are told off entirely for the drag-ropes, the other men at the gun also assisting in manning them: No. 9 is always in the shafts, and No. 8 at the point of the shaft, near side. A 9 pounder requires additional men, and a double set of drag-ropes.

2. The drag-rope men are numbered off from 10 upward. Nos. 10, 12, 14, are with the left drag-rope; 11, 13, 15, with the right; 10, 11, carry the drag-ropes.

3. The gun being limbered up, and the detachment and drag-rope men in the order of march, at the word "HOOK ON," Nos. 8 and 9 get into their places; 10, and 11 move outside the gun detachments to the rear, and hook on to the gun drag-washers, passing the end of the drag-ropes at once to the front.

The Nos. then man the drag-ropes as follows:—Nos. 10, and 11 outside, close to the drag-washer; 2, 12, 3, and 13 the centre of the drag-rope; 4, 14, 5, and 15 the front; 6, and 7 the ends. The gun detachments inside, and the drag-rope men outside. No. 1 at the point of the shafts, off-side. At the word "UNHOOK," Nos. 10, and 11 unhook, coil up the drag-ropes; and the whole then form the order of march.

4. At the word "ACTION," whether to the "FRONT," "REAR,' "RIGHT," or "LEFT," the drag-ropes are at once quitted; Nos. 10, and 11 unhook, and coil them up; and the whole of the drag-rope men retire with the limber, forming in front of it two deep, as they were numbered off. In limbering up, the drag-rope men form the order of march, and wait for the word to hook on.

FORMATION OF A BATTERY.

A battery of Artillery is generally composed of six pieces of ordnance, to which a Company of Artillery is attached. The number of ammunition, forge, and store waggons varies according to the nature of the ordnance.

Section 19. *Fitting of saddles, bridles, harness, &c.*

Section 20. *Harnessing.*

Section 21. *Carrying forage.*

Section 22. *Instruction for Drivers.*

Section 23. *Parade, and inspection.*

The Battery, limbered up, is told off by sub-divisions, divisions, and half batteries.

One gun and its waggon constitute a sub-division.		
Two sub-divisions	„	a division.
Three sub-divisions	„	a half battery.

The battery is numbered from right to left by sub-divisions. It is then told off into three divisions. No. 1 the right; No. 2 the centre; No. 3 the left. Sub-divisions Nos. 1, 3, and 5 are also distinguished as right sub-divisions of divisions; and Nos. 2, 4, and 6 the left; the two centre sub-divisions are also to be named. It is also told off into half batteries, and these are distinguished by right, centre, and left sub-divisions of half batteries. The gun of direction should always be named. A flank gun is generally named with a battery of four guns, and the right centre gun with a battery of six guns.

Spare carriages, with the battery, form a third, and, if necessary, a fourth line, in rear.

Section 24. *Posts, and duties of Officers, and mounted Non-commissioned officers, &c., at exercise.*

Second Captain.

In line, limbered up.—One horse's length in rear of the centre.

In column.—Two horses' length from the centre on the reverse flank.

In action.—He assists the Captain in general superintendence.

He dresses all points of formation, gives the word "*Steady,*" when they have been correctly taken up, and the formation completed. When required he commands a division.

Subalterns.

In line, limbered up.—The senior on the right of the right division; the second on the left of the left division; the junior on the right of the centre division.

In column of route.—On the pivot flanks of their leading sub-divisions.

In column of divisions.—On the pivot flanks of their respective divisions.

In column of half batteries.—The subaltern of the centre division, on the pivot flank of the leading half battery. The others continue on the same flank of their sub-divisions as when in line.

In action.—Between the guns of their divisions, a little in rear.

They command the divisions to which they are attached, dressing in line with, and close to the leaders, and always with the guns.

In shifting from one flank to the other.—It is always along the front, and at a canter; and in joining the new sub-division, the officer always turns his horse's head inwards.

Staff Serjeants.

In line, limbered up.—The senior on the right of the marker of the right division. The junior on the left of the marker of the left division.

In column of route.—One on the reverse flank of the leading gun; the other on the pivot flank of the rear carriage.

In column of divisions.—One between the guns of the leading, the other between the guns of the rear division.

In column of half batteries.—On the reverse flank of the waggons of each half battery.

They take up points in changes of position. In line formations, 10 yards from the flank sub-divisions; in column formations, 10 yards in front, and rear. They dress the markers when there is no staff-officer; and the limbers, and waggons in action.

Markers.

In line, limbered up.—In line with the leaders of the waggons, and covering their officers.

In column of route.—With their leading waggons covering their officers. (Without waggons, covering their officers, and in line with the centre horses of the gun.)

In column of divisions, and half batteries.—They cover their officers. (Without waggons, on the reverse flank of their divisions.)

In action.—Those of the right, and centre divisions on the right of the leaders of the limbers of their right sub-divisions. The marker of the left division, on the left of the leaders of the limber of the left sub-division.

They take up points in changes of position; in line formations, for the sub-division nearest the one of formation; in column formations, for the pivot sub-division.

Farriers, and Artificers.

The farrier is generally attached to the forge; but when the battery is limbered up he is in the centre, in rear of the second captain. The other artificers are told off in the gun detachments when not mounted.

Trumpeters.

In line, limbered up.—On the right of the battery, in line with it, one horse's length distant.

In column.—One horse's length in front.

During manœuvres.—One with the commander; the other in rear of the battery.

MANŒUVRES OF A BATTERY OF SIX PIECES.

Section 25. BATTERY IN LINE.

1. *To advance.*

*THE BATTERY WILL ADVANCE—MARCH.	*The officer, and marker of the sub-division of direction take up points.*

2. *To retire.*

RIGHT (OR LEFT) REVERSE—MARCH.	

3. *To come into action.*

ACTION FRONT.	*Senior staff-serjeants.*—Left reverse.

4. *To diminish* (*or increase*) *intervals on the march.*

To diminish. HALF, OR QUARTER, INTERVALS ON—SUB-DIVISION.	*Nos.* 1. Right (or left) half turn—Trot—Front turn—Walk (except No. 1 of the named sub-division).
To increase. FULL INTERVALS ON—SUB-DIVISION.	*Nos.* 1. Left (or right) half turn—Trot—Front turn—Walk (except No. 1 of the named sub-division).

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* The Commanding officer's Word of command is always to be repeated by the officers.

5. *To take ground to a flank.*

RIGHT (OR LEFT) TAKE GROUND— MARCH.	*The officers shift to the pivot flank of what will become their leading sub-divisions.*

6. *To make a half turn on the march.*

RIGHT (OR LEFT) HALF TURN—MARCH.	

7. *To form Column of divisions in rear of a flank.*

FORM COLUMN OF DIVISIONS IN REAR OF THE RIGHT.	*Centre division*—Right reverse—March—By the left—Left take ground—Left take ground—Halt—Dress.
MARCH.	*Left division*—Right reverse—March—By the left—Left half turn—Left half turn—Left take ground—Halt—Dress.
FORM COLUMN OF DIVISIONS IN REAR OF THE LEFT.	*Centre division*—Left reverse—March—By the right—Right take ground—Right take ground—Halt—Dress.
MARCH.	*Right division*—Left reverse—March—By the right—Right half turn—Right half turn—Right take ground—Halt—Dress.

8. *To form Column of divisions in front of a flank.*

FORM COLUMN OF DIVISIONS IN FRONT OF THE LEFT—	*Centre division*—Forward—March—Left take ground—Waggons close intervals—Right take ground—Halt—Dress.
MARCH.	*Right division*—Forward—March—Left half turn—Left half turn—Waggons close intervals—Right take ground—Halt—Dress.
FORM COLUMN OF DIVISIONS IN FRONT OF THE RIGHT—	*Centre division*—Forward—March—Right take ground—Waggons close intervals—Left take ground—Halt—Dress.
MARCH.	*Left division*—Forward—March—Right half turn—Right half turn—Waggons close intervals—Left take ground—Halt—Dress.

9. *To form Column of divisions on the centre division.*

This manœuvre is a combination of Nos. 7 and 8.

10. *To change front to the rear.*

First method. By a countermarch.

THE BATTERY WILL CHANGE FRONT TO THE REAR. GUNS RIGHT, WAGGONS LEFT TAKE GROUND— MARCH.	*The officers shift to the pivot flank of their leading guns—viz., to the left of* 1, 3, *and* 5 *guns.*
RIGHT COUNTERMARCH—FRONT TURN—HALT—DRESS.	

Second method. On the centre.

CHANGE FRONT TO THE REAR ON THE CENTRE —MARCH.	*Centre division*—Sub-divisions inwards about wheel—March—Halt—Dress. *Right division*—March—Left wheel—Left wheel—Halt—Dress. *Left division*—March—Right wheel—Right wheel—Halt—Dress.

Third method. When at diminished intervals; on the march.

THE BATTERY WILL CHANGE FRONT TO THE REAR; ON THE CENTRE. LEFT HALF BATTERY — HALT. HALF BATTERIES INWARDS ABOUT WHEEL —FORWARD.	

11. *To change front to a flank.*

First method. Right (or left) back, on a flank sub-division.

	Nos. 1.
CHANGE FRONT TO THE RIGHT ON No. 6. MARCH.	6. Left wheel—Left about wheel—Halt—Dress. 5. 4. 3. 2. 1. Right reverse. Left shoulders. Right reverse. Halt—Dress.

	Nos. 1.
CHANGE FRONT TO THE LEFT ON No. 1. MARCH.	1. Right wheel—Right about wheel—Halt—Dress. 2. 3. 4. 5. 6. Left reverse. Right shoulders. Left reverse. Halt. Dress.

For Action.

CHANGE FRONT TO THE RIGHT, ON No. 6, FOR ACTION. MARCH. (OR CHANGE FRONT TO THE LEFT ON No. 1, FOR ACTION. MARCH.)	*The named sub-division comes into action in the new direction; the others proceed as before, and come into action to the rear.*

Second method. Right (or left) forward, on a flank sub-division.

	Nos. 1.
CHANGE FRONT TO THE LEFT ON No. 6. MARCH.	6. Right wheel—Right about wheel—Halt—Dress.

	Nos.	
	5. 4. 3. 2. 1.	Right shoulders. Halt—Dress.
	Nos. 1.	
CHANGE FRONT TO THE RIGHT ON No. 1—MARCH.	1.	Left wheel—Left about wheel—Halt—Dress.
	2. 3. 4. 5. 6.	Left shoulders. Halt. Dress.

For Action.

CHANGE FRONT TO THE RIGHT ON No. 1 FOR ACTION—MARCH—(OR CHANGE FRONT TO THE LEFT ON No. 6, FOR ACTION—MARCH).	*The named sub-division comes into action in the new direction; the others proceed as before, and come into action to the front.*

Third method. To the right (or left) on a central sub-division, one flank thrown forward, the other back. This is a combination of the First, and Second methods.

Note.—A battery may change its front, Half right, or Half left, on the same principle as already detailed. The commanding officer's word would be "CHANGE FRONT, HALF RIGHT (or HALF LEFT) ON —SUB-DIVISION."

These manœuvres can be executed on the same principle, by divisions, or half batteries.

A Battery can also change front on a moveable pivot, by a simple wheel.

12. *To advance from a flank, in column.*

ADVANCE FROM THE RIGHT, IN COLUMN OF DIVISIONS—MARCH.	*Right division.*	Forward by the left. March.
	Centre, and left divisions . . .	Right take ground. March — Left take ground.
	Nos. 1.	
	2. 4.	Waggon right. Waggon rear.
ADVANCE FROM THE LEFT, IN COLUMN OF DIVISIONS—MARCH.	*Left division* . .	Forward by the right —March.
	Centre, and right divisions. . .	Left take ground— March. Right take ground.
	Nos. 1.	
	5. 3.	Waggon left. Waggon rear.

13. *To advance from the centre, in double column of sub-divisions.*

ADVANCE FROM THE CENTRE IN A DOUBLE COLUMN OF SUB-DIVISIONS—MARCH.	*Centre division* — Forward. — Trot — March. *Right division*—Left take ground—March. *Left division*—Right take ground—March. *Nos.* 1. 2. } Right take ground—Trot. 1. } Right take ground. 5. } Left take ground—Trot. 6. } Left take ground.

14. *To move from a flank along the front in a column of divisions.*

MOVE FROM THE RIGHT, ALONG THE FRONT, IN COLUMN OF DIVISIONS. MARCH.	Forward—March. Left wheel.

Note.—To advance from the left, along the front, is done in the same manner.

15. *To advance from a flank, in echellon of sub-divisions.*

ADVANCE FROM THE RIGHT, IN ECHELLON OF SUB-DIVISIONS—MARCH.	

Advancing from the Left is done on the same principle.

Note.—A Battery in echellon of Sub-divisions, if required to change its front when in action, can do so at the word "ACTION LEFT" (OR RIGHT), by merely throwing the trails round, and bringing the guns into the new direction, the limbers, and waggons forming in rear of their guns.

16. *To advance from a flank in echellon of divisions.*

ADVANCE FROM THE RIGHT; IN ECHELLON OF DIVISIONS—MARCH.	*The right division advances, the centre moves off in succession, when at its wheeling distance, in rear of the leading one. The left division follows in the same manner.*

Advancing from the Left is done on the same principle.

Note.—A Battery in echellon of Divisions, if required to change its front when in action, does so as follows:—

CHANGE FRONT TO THE LEFT, ON THE LEFT GUNS OF DIVISIONS—MARCH.	*Nos.* 1. 2. } 4. } Action left. 6. } 1. } Front limber up. 3. } Left wheel—Halt. 5. } Action front.

An echellon of Half batteries is formed in the same manner as that of divisions; the rear half battery must, however, keep its wheeling distance from the leading one. When in action, if the front is to be changed, it is better to do it on a centre gun.

Retirements in echellon, are done on the same principle as the advance.

17. *To retire from a flank in column.*

First method.

RIGHT DIVISION TO THE REAR—MARCH.	*Right division*—Sub-divisions inwards about wheel—March. *Centre, and left divisions*—Forward—March—Right wheel—Right wheel.

To retire with the Left division is done on the same principle.

Second method.

RETIRE FROM THE RIGHT IN COLUMN OF DIVISIONS—MARCH.	*Right division*—Right reverse—March. Centre, and left divisions . . . } Right take ground—March—Right take ground. *Nos.* 1. 2. } Gun left. 4. } Gun rear.

18. *To retire from the centre in a double column of sub-divisions.*

In order to perform this manœuvre, the battery should be reversed, and then (with waggons leading) it is performed in the same manner as the advance from the centre, in a double column.

19. *To retire from a flank by alternate Half batteries, in action.*

When a battery in line, in action, is ordered to retire from a flank by alternate Half batteries, the named half battery at once limbers up to the rear, retires to its distance in echellon, and comes into action. As soon as this half battery is in action, the other limbers up to the rear, retires, passes the half battery in action, and so on. The senior officer of each half battery gives the word of command.

Note.—This manœuvre would generally be practised with the prolonge.

20. *To break into column to a flank.*

BREAK INTO COLUMN OF DIVISIONS TO THE RIGHT. MARCH.	*Nos.* 1. 1. 3. 5. } Right take ground. Guns front. 2. 4. 6. } Right wheel.

Breaking into Column to the Left can be done on the same principle.

A Column of Half batteries can be formed in the same manner; the pivot sub-divisions wheeling as before, but the others, after taking ground, must incline away to gain their required intervals.

Note.—This movement would generally be employed in breaking into column from line, to march past with other troops; and with half batteries it would be done at reduced intervals.

21. *To increase, and diminish the front.*

First method.

From Column of route, to form Column of divisions, on the march.

Column, right in front.

FORM COLUMN OF DIVISIONS.	*Nos.* 1. 2. 4. 6. } Left half turn—Trot. Front turn. *Right division*—Forward by the left. *Centre, and left divisions.* } Forward by the left. Trot—Walk.

Column, left in front.

FORM COLUMN OF DIVISIONS.	*Nos.* 1. 5. 3. 1. } Right half turn—Trot. Front turn. *Left division*—Forward by the right. *Centre, and right divisions.* } Forward by the right—Trot. Walk.

Second method.

From Column of route, to form Column of divisions, in succession.

Column, right in front.

IN SUCCESSION FORM COLUMN OF DIVISIONS.	*Nos.* 1. 1. 3. 5. } Halt. 2. 4. 6. } Left half turn. Front turn. Halt—Dress.

Column, left in front.

IN SUCCESSION FORM COLUMN OF DIVISIONS.	*Nos.* 1. 6. 4. 2. } Halt. 5. 3. 1. } Right half turn. Front turn. Halt—Dress.

Third method.

From Column of divisions, to form Column of route, on the march.

Column, right in front.

FORM COLUMN OF ROUTE.	*Centre, and left divisions.* Halt. *Nos.* 1. 1. Forward. 3. 5. } Forward—March. 2. 4. 6. } Halt.—Right half turn—March. Front turn.

Column, left in front.

FORM COLUMN OF ROUTE.	*Centre, and right divisions*—Halt. *Nos.* 1. 6. Forward. 4. 2. } Forward—March. 5. 3. 1. } Halt. Left half turn.—March—Front turn.

22. *To bring the Rear to the front, in succession, on the march.*
First method. In Column of route.

REAR SUB-DIVISION TO THE FRONT.	*Nos.* 1. 6. 5. 4. 3. 2. } *In succession* { Right half turn. Front turn.

Second method. In Column of divisions.

REAR DIVISION TO THE FRONT THROUGH THE INTERVALS.	*Centre, and rear divisions in succession.* Inwards close—Forward—Full intervals.

23. *To form Line on the leading division.*
Divisions, right in front.

LEFT OF THE FRONT FORM LINE—MARCH.	*Centre division*—Left take ground—March—Right take ground—Halt—Dress. *Left division*—Left take ground—March—Right half turn—Right half turn—Halt—Dress.

Divisions, left in front.

RIGHT OF THE FRONT FORM LINE—MARCH.	*Centre division*—Right take ground—March—Left take ground—Halt—Dress. *Right division*—Right take ground—March—Left half turn—Left half turn—Halt—Dress.

On the March.

The centre, and rear divisions make a half turn towards the intended line, and come up at an increased pace.

For Action.

RIGHT (OR LEFT) OF THE FRONT FORM LINE FOR ACTION—MARCH.	Halt—Action front.

24. *To form Line on the rear division.*

Divisions, right in front.

RIGHT OF THE REAR FORM LINE—MARCH.	*Centre division*—Right take ground—March—Right take ground—Right reverse—Halt—Dress. *Right division*—Right take ground—March—Right half turn—Right half turn—Right reverse—Halt—Dress.

Divisions, left in front.

LEFT OF THE REAR FORM LINE—MARCH.	*Centre division*—Left take ground—March—Left take ground—Left reverse—Halt—Dress. *Left division*—Left take ground—March—Left half turn—Left half turn—Left reverse—Halt—Dress.

For Action.

RIGHT (OR LEFT) OF THE REAR, FORM LINE FOR ACTION, FRONT—MARCH.	*The standing division comes into action to the front: the others, as they arrive in line, come into action to the rear.*

25. *To form Line on the centre division.*

This manœuvre is a combination of Nos. 23, and 24.

26. *To form Line to the rear on the leading division.*

Divisions, right in front.

FORM LINE TO THE REAR, ON THE LEADING DIVISION—MARCH.	*Right division*—Sub-divisions inwards about wheel—March—Halt—Dress. *Centre division*—Right take ground—March—Left take ground—Sub-divisions inwards about wheel—Halt—Dress. *Left division*—Right take ground—March—Left half turn—Left half turn—Sub-divisions inwards about wheel—Halt—Dress.

Divisions, left in front.

FORM LINE TO THE REAR, ON THE LEADING DIVISION—MARCH.	*Left division*—Sub-divisions inwards about wheel—March—Halt—Dress. *Centre division*—Left take ground—March—Right take ground—Sub-divisions inwards about wheel—Halt—Dress. *Right division*—Left take ground—March—Right half turn—Right half turn—Sub-divisions inwards about wheel—Halt—Dress.

27. *To form Line to the rear on the rear division.*

Divisions, right in front.

FORM LINE TO THE REAR, ON THE REAR DIVISION—MARCH.	*Right division*—Left wheel—March—Right shoulders—Right shoulders—Halt—Dress. *Centre division*—Left wheel—March—Left wheel—Halt—Dress. *Left division*—Sub-divisions inwards about wheel—March—Halt—Dress.

Divisions, left in front.

FORM LINE TO THE REAR, ON THE REAR DIVISION—MARCH.	*Left division*—Right wheel—March—Left shoulders—Left shoulders—Halt—Dress. *Centre division*—Right wheel—March—Right wheel—Halt—Dress. *Right division*—Sub-divisions inwards about wheel—March—Halt—Dress.

28. *To form Line to the rear on the centre division.*

This is a combination of Nos. 26, and 27.

29. *To form Line to the reverse flank on the leading division.*

Divisions, right in front.

FORM LINE TO THE RIGHT FLANK ON THE LEADING DIVISION—MARCH.	*Right division*—Right wheel—March—Halt—Dress. *Centre, and left divisions*—Left half turn—March—Front turn—Right wheel—Halt—Dress.

Divisions, left in front.

FORM LINE TO THE LEFT FLANK ON THE LEADING DIVISION—MARCH.	*Left division*—Left wheel—March—Halt—Dress. *Centre, and right divisions*—Right half turn—March—Front turn—Left wheel—Halt—Dress.

30. *To wheel into Line.*

Divisions, right in front.

LEFT WHEEL INTO LINE—MARCH.	*Nos.* 1.	
	1. 3. 5.	Sub-divisions, left wheel—Halt—Dress.
	2. 4. 6.	Sub-divisions, right wheel—Right about wheel—Halt—Dress.

Divisions, left in front.

RIGHT WHEEL INTO LINE—MARCH.	*Nos.* 1.	
	2. 4. 6.	Right wheel. Halt—Dress.

Nos.
1. 3. 5. } Left wheel—Left about wheel.
Halt—Dress.

31. *To deploy on the rear division.*

Note.—All deployments are on the front base.

Divisions, right in front.

DEPLOY ON THE REAR DIVISION—MARCH.	*Right division*—Right take ground—March—Right take ground—Right reverse—Halt—Dress. *Centre division*—Right take ground—March—Left take ground—Halt. March—Halt—Dress. *Left division*—Forward—March—Trot—Halt—Dress.

Divisions, left in front.

DEPLOY ON THE REAR DIVISION—MARCH.	*Left division*—Left take ground—March—Left take ground—Left reverse—Halt—Dress. *Centre division*—Left take ground—March—Right take ground—Halt. March—Halt—Dress. *Right division*—Forward—Trot—March—Halt—Dress.

For Action.

DEPLOY ON THE REAR DIVISION, FOR ACTION FRONT—MARCH.	The Divisions all proceed as before, except that the leading division, instead of going to the rear and reversing, comes into action to the right, or left, when in its place; the other divisions come into action to the front.

32. *To deploy on the Centre division.*

DEPLOY ON THE CENTRE DIVISION—MARCH.	*Right division*—Right take ground—March—Right take ground—Right reverse—Halt—Dress. *Centre division* — Forward — Trot — March—Halt—Dress. *Left division*—Left take ground—March—Right take ground—Halt—Dress.

33. *To countermarch.*

THE COLUMN WILL COUNTERMARCH—DIVISIONS BY SUB-DIVISIONS INWARDS ABOUT WHEEL—MARCH. HALT—DRESS.	*The Sub-divisions wheel about* inwards, and halt on their markers. The officers moving up with their sub-divisions.

On the March.—The markers fall in rear of their officers.

34. *From Double column of sub-divisions to form line to the front.*

RIGHT, AND LEFT OF THE FRONT, FORM LINE—MARCH.	*Nos.* 1.
	2. Right half turn—Front turn.
	1. Halt—Dress.
	5. Left half turn—Front turn.
	6. Halt—Dress.

On the March.—The rear sub-divisions move up at an increased pace.

For Action.—At the word "MARCH," the two leading sub-divisions come into action to the front: the other sub-divisions come into action, in succession, as they arrive in line.

35. *From Double column of sub-divisions, to form line to a flank.*

FORM LINE TO THE RIGHT, ON THE RIGHT HALF BATTERY—MARCH.	*Nos.* 1.
	3. Right wheel—Halt—Dress.
	2. Forward—Right wheel.
	1. Halt—Dress.
	4. 5. 6. Forward—Right wheel. Halt—Dress.

To form Line to the left is done on the same principle.

INSPECTION, AND REVIEW.

A single Battery.

The Battery is formed in line limbered up; the detachments in the order of march.

The waggons at order—viz., ten yards in rear of their guns.

The Officers at order—viz., the Subalterns one horse's length in front of, and in the centre of their divisions.

The second Captain on the right of the battery, in line with the Subalterns.

The Staff serjeants on the outer flanks of the waggons.

The Markers move up into the places of their officers.

The Commanding officer in the centre of the battery, one horse's length in front of the Subalterns.

As the Inspecting Officer arrives, the Officers draw swords and salute; taking the time from the Commanding officer, whose word of command is "GENERAL SALUTE, DRAW SWORDS." The officers then recover their swords in like manner. As soon as the inspection has been made, the Commanding officer gives the word, "TAKE CLOSE ORDER—MARCH," when the officers, and markers return to their places in line, the officers sloping their swords; and the waggons move up.

Marching past.

This may be done either by Divisions, or by Half batteries; in the latter case usually at half intervals.

THE BATTERY WILL MARCH PAST.

BREAK INTO COLUMN OF DIVISIONS (OR HALF BATTERIES AT HALF INTERVALS) TO THE RIGHT—MARCH.

At thirty yards from the Inspecting officer, the Subaltern officers in command of divisions, or half batteries, give the word, "Carry swords, eyes right," and move out one horse's length in the front of, and in the centre of their divisions. In Half batteries, the two officers of the leading half battery between the guns of it; the officer of the rear half battery in front of his centre gun. The Commanding Officer two horses' length in front of the battery, and the Second Captain in rear of the battery. The officers salute at six yards' distance from the Inspecting officer, and recover their swords at ten yards past him. At twenty yards past, the Subaltern officers in command of divisions (or half batteries) give the word, "Eyes front—Slope swords."

In trotting past the detachments are mounted; the officers remain on the flanks, and carry swords as they pass the Inspecting officer, giving the word, "Eyes right—Carry swords."

Should a battery be required to *rank* past, it wheels as before, until it arrives on the line of the Inspecting officer, when it halts.

THE BATTERY WILL RANK PAST—MARCH.

The battery advances in a column of route, the officers in front of the guns, the markers, staff-serjeants, and farrier in front of the waggons. The officers, and drivers salute, as before. The spare carriages in rear of the divisions to which they belong: the second Captain in rear of the whole.

EQUIPMENT OF A BATTERY.

Sec. 1. *Packing the Intrenching tools, Camp equipage, &c., &c.*

1.—In equipping a battery for the march, the stores, intrenching tools, camp equipage, &c., are packed as follows:—

On gun limber.

Two carbines on the front of the boxes, barrels up.
Two fitting ropes on the foot board.
One swingletree between the foot board, and the splinter bar.
One felling axe on the splinter bar, edge inwards.
One bill hook under the foot board.
Two spades on the sides of the boxes, and fastened to the splinter bar.
One grease tin on the front of the axletree.
One pickaxe under the axletree.
One prolonge between the boxes, above the washer box.
Two water buckets on the back of the axletree.
Two corn sacks; two blankets folded (21 inches by 16), in blanket covers, on the box lids.

On gun carriage.

One claw hammer } On each cheek.
One wrench hammer }
One pair of pincers on the cheek.
One spare sponge, wadhook, and handspike, under the trail.
Two camp kettles in rear of axletree.

The whole of these stores, &c., are buckled on by Nos. 1, and 6.

On waggon limber.

One picket line on the foot board.
One lifting jack on the foot board.
One grease tin on the front of the axletree.
Two corn sacks, two blankets folded, in blanket covers, on the box lids.

These stores are buckled on by Nos. 4, and 5.

On waggon body.

Four picket posts, two on each side of the boxes.
One maul under off end of rear foot board.
Spare horse-shoe box, under the front foot board.
Grease magazine under near end of rear foot board.
Four blankets, in blanket covers, on the box lids.
One camp kettle on the rear of the axletree.

These stores are buckled on by Nos. 2, 3, 7, and 8.

Twenty-three tents are supplied to a battery: each of the six Sub-divisions having 4 tents, except No. 3 Sub-division, which has 3 tents. The tents, and tent pins in valises, are carried on waggon body.

6-POUNDER GUN.

LIMBER.

1 Carbine. Felling-axe.
Grease-tin.

2 Drag-ropes.
Swingletree.

1 Carbine.
Bill-hook.

Spade.

4 c. case. 2 files. 2 funnels. 1 box con. 12 fuzes. 1 knife. 1 mallet. 1 setter. 2 needles. 1 pincers. 1 saw set. 1 scissors. 1 oz. worst. 1 set fuze borers.	8 solid shot. 13, 1½ lb. cartridges. 6 port-fires, & 1 saw, on lid. 2 straps for fuze-boxes. 2 keys. 2 drivers.	8 shrapnel. 9, 1½ lb. cartridges. 1 copy of Instructions for fixing fuzes. 5 fuze sections.

prolonge.

1 washer. 1 linchpin. 2 couples.
1 ram. head.

8 solid shot. 11, 1½ lb. cartridges. 100 friction tubes, in box.	8 solid shot. 13, 1½ lb. cartridges.	4 common case. Tube pocket. 3 lanyards.

Spade.

Water-bucket.

Pickaxe. Water-bucket.

TRAIL.

The stores on the gun-carriage are buckled on by Nos. 1, and 6.

The fitting-ropes are substitutes for drag-ropes.

Sponge.

2 ptfire-stks. 2 handsp.

Spare sponge, and wadhook, underneath the trail.

1 common case.	1 common case.	1 common case.
3 solid shot.		

pincers. wrench. hammer.

claw hammer.

2 punches. 2 com. spikes. 1 spring ditto. 1 spunge head. 2 thumb stalls. 1 sp. tangent screw. priming irons.	3 lbs. slow match.

Camp kettle.

GUN

Camp kettle.

6-POUNDER GUN AMMUNITION WAGGON.

LIMBER.

Picket-line. Felling-axe.
Grease-tin.

Spade.

4 solid shot (above). 4 common case (below). 6 portfires on lid.	8 solid shot. 12, 1½ lb. cartridges.	8 shrapnel. 12, 1½ lb. cartridges. 1 blue box containing 12 shrapnel fuzes.

Water-bucket.

The stores on the waggon limber are buckled on by Nos. 4, and 5.

1 washer. 1 linchpin. 2 couples.

(Spare wheel.)

Bill-hook.
Swingletree.

8 solid shot. 12, 1½ lb. cartridges. 1 box containing 100 fric. tubes.	8 solid shot. 12, 1½ lb. cartridges.	4 solid shot. 4 common case.

Spade.

Pickaxe. Water-bucket.

The stores on the waggon body are buckled on by Nos. 2, 3, 7, 8.

10 sets of horse-shoes.

20 solid shot, in 2 tiers. 12, 1½ lb. cartridges.	10 shrapnel. 16, 1½ lb. cartridges. 1 bag con. 12 fuzes. 1 box con. 100 friction tubes.	15 solid shot. 27, 1½ lb. cartridges. 1 tube pocket. 1 skein of marline.

10 sets of horse-shoes.

Tent-poles, picket-posts.
Hand-saw in leather case.

15 solid shot. 27, 1½ lb. cartridges. 100 empty flannel cartridges. 7½ lbs....	10 solid shot. 18, 1½ lb. cartridges. 1 skein of Hambro' line. .... slow	30 solid shot, in 3 tiers. .... match.

Tent-poles, picket-posts.

Camp-kettle, grease-mag., reaping-hooks, maul, camp-kettle.
Tent-pegs, and tents on foot-boards. 10 sets horse-shoes.
Blankets, and corn sacks on limber boxes.

12-POUNDER HOWITZER.

LIMBER.

1 carbine. Felling-axe. Grease-tin.		2 drag-ropes. Swingletree.		1 carbine. Bill-hook.	
12 shrapnel, in 2 tiers. 2 files. 2 funs. 1 box con. 12 shrap. fuzes. 1 knife. mallet. 2 setters. 1 saw set. 2 needles. 1 pincers. 1 scissors. 1 oz. worsted. 1 set of fuze borers. 2 keys. 2 drivers.	6 shrapnel. 18, 1¼ lb. cartridges. 2 fuze boxes, 12 in each. 1 copy of Instructions for fixing fuzes. 5 fuze sections. 2 straps for fuze boxes. 6 portfires, and 1 saw on lid.	prolonge. 1 washer. 1 linchpin. 2 couples.	2 common shells. 4 common case. 18, 1¼ lb. cartridges.	12 common shells, in 2 tiers. Tube pocket. 1 box contain. 100 friction tubes. 1 black box containing 8 com. fuzes. 1 black bag containing 16 common fuzes. 3 lanyards.	

Spade. Spade.

Water-bucket. Pickaxe. Water-bucket.

TRAIL.

The stores on the gun-carriage are buckled on by Nos. 1, and 6.

The fitting-ropes are substituted for drag-ropes.

Sponge. 2 ptfire stks. 2 handsp. Spare sponge, and wadhook, underneath the trail.

1 rammer head. 1 set of priming-irons. 1 sponge head.	pincers. wrench. hammer.	claw hammer.	2 punches. 2 com. spikes. 1 spring ditto. 2 thumb-stalls. 1 sp. tangent screw.	3 lb. slow match.

Camp-kettle. Camp-kettle.

HOW.

12-POUNDER HOWITZER AMMUNITION WAGGON.

LIMBER.

Picket-line. Felling-axe.
Grease tin.

Bill-hook.
Swingletree.

Spade.

12 shrapnel, in 2 tiers. 72 fuzes, in 4 bundles. 1 blue bag con. 12 shrap. fuzes. 1 blue box con. 12 shrap. fuzes. 6 portfires on lid.	6 shrapnel. 18, 1¼ lb. cartridges.

1 washer. 1 linchpin. 2 couples.

2 common shells. 4 common case. 18, 1¼ lb. cartridges.	12 common shells, in 2 tiers. 2 black boxes, each containing 8 common fuzes. 100 tubes. Tube pocket.

Spade.

Water-bucket.

Pickaxe. Water-bucket.

The stores on the waggon limber are buckled on by Nos. 4, and 5.

The stores on the waggon body are buckled on by Nos. 2, 3, 7, 8.

(Spare wheel.)

10 sets of horse-shoes.

16 shrapnel, in 2 tiers. 8, 1¼ lb. cartridges. 3 blue bags, each con. 12 shrap. fuzes.	28, 1¼ lb. cartridges.	16 shrapnel, in 2 tiers.

10 sets of horse-shoes.

Tent-poles, picket-posts.
Hand-saw in leather case.

16 common shells, in 2 tiers. 100 empty flannel cartridges.	28, 1¼ lb. cartridges.	4 com. shells. 4 carcasses, (below). 8 com. shells, (above). 1 skein Hambro' line, 1 do. marline. 2 black bags, each containing 16 common fuzes.

Tent-poles, picket-posts.

Camp-kettle, grease-mag., reaping-hooks, maul, camp-kettle.
Tent-pegs and tents on foot-boards. 10 sets of horse-shoes.
Blankets, and corn sacks on limber boxes.

9-POUNDER GUN.

LIMBER.

1 Carbine. Felling-axe.
Grease-tin.

2 Drag-ropes.
Swingletree.

1 Carbine.
Bill-hook.

Spade.

4 com. case. 2 files. 1 knf. 2 funnels. 1 blue box containing 8 shrap. fuzes. 1 mallet. 2 needles. 1 pincers. 1 saw set. 1 scis. 1 setr. 1 oz. worstd. 1 set fu. borers. 2 straps for fu. boxes.	6 solid shot. 8, 2½ lb. cartridges. 6 portfires & 1 saw, on lid.
	6 shrapnel. 8, 2½ lb. cartridges. 5 fuze sections. 1 copy of Instructions for fixing fuzes. 2 drivers. 2 keys.

Water-bucket.

Prolonge.

2 washers. 2 linchpins. 2 coups.
1 r. head.

6 solid shot. 8, 2½ lb. cartridges.	4 com. case. 1 tube pocket. 100 friction tubes. 3 lanyards.
6 solid shot. 8, 2½ lb. cartridges.	

Spade.

Pickaxe. Water-bucket.

TRAIL.

The stores on the gun-carriage are buckled on by Nos. 1, and 6.

The fitting-ropes are substitutes for drag-ropes.

Sponge.

2 portfire-sticks. handspike.

Spare sponge, and wadhook, underneath the trail.

1 set priming-irons. 1 sponge head.

Camp-kettle.

pincers. wrench. hammer.

claw-hammer.

2 punches. 2 com. spikes. 1 spring ditto. 2 thumb-stalls. 1 spare tangent screw.	3 lb. slow match.

Camp-kettle.

GUN.

9-POUNDER GUN-AMMUNITION-WAGGON.

LIMBER.

Picket-line. Felling-axe.
Grease-tin.

Spade.	4 common case. 50 empty flannel cartridges. 1 blue box containing 8 shrapnel fuzes.	6 solid shot. 8, 2½ lb. cartridges. 6 portfires on lid. 6 shrapnel. 8, 2½ lb. cartridges.	

Water-bucket.

1 washer. 1 linchpin. 2 couples.

Lifting-jack. Bill-hook.
Swingletree.

	6 solid shot. 8, 2½ lb. cartridges. 6 solid shot. 8, 2½ lb. cartridges.	4 common case. 1 tube pocket. 100 friction tubes.	Spade.

Pickaxe. Water-bucket.

The stores on the waggon limber are buckled on by Nos. 4, and 5. (Spare wheel.) The stores on the waggon body are buckled on by Nos. 2, 3, 7, 8.

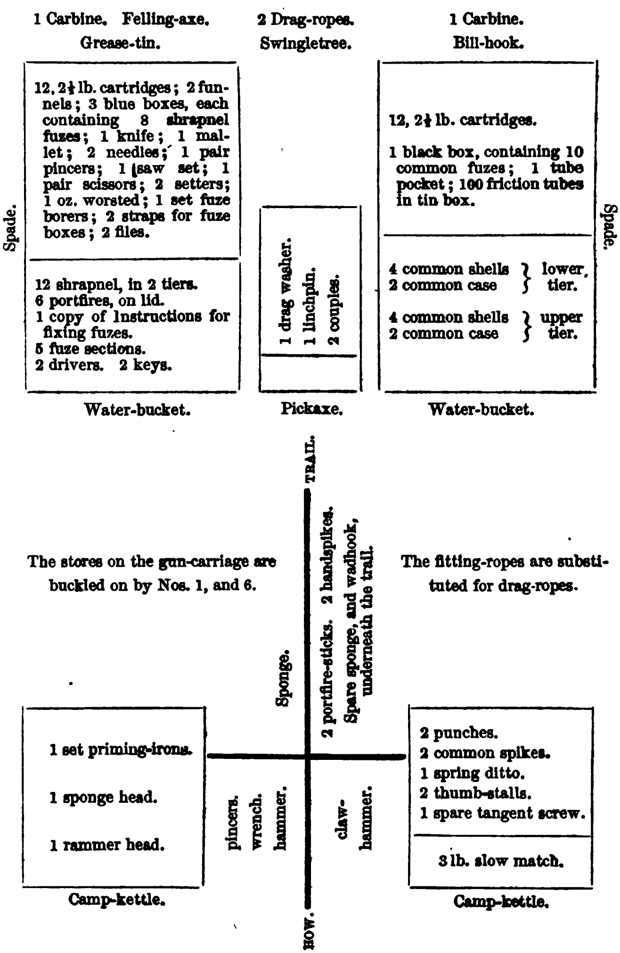
10 sets of horse-shoes.	16 solid shot. 9, 2½ lb. cartridges.	8 shrapnel. 13, 2½ lb. cartridges. 1 box containing 8 fuzes.	8 solid shot. 14, 2½ lb. cartridges.	10 sets of horse-shoes.

Tent-poles, picket-posts. Hand-saw, in leather case.	8 solid shot. 14, 2½ lb. cartridges. 6 lb.	8 solid shot. 14, 2½ lb. cartridges. . . . slow . . .	16 solid shot, in 2 tiers. 50 empty flannel cartridges. 1 skein marline. 1 skein Hambro' line. . . . match.	Tent-poles, picket-posts.

Camp-kettle, grease-mag., reaping-hooks, maul, camp-kettle.
Tent-pegs and tents on foot-boards. 10 sets horse-shoes.
Blankets, and corn sacks on limber boxes.

24-POUNDER HOWITZER.

LIMBER.



1 Carbine. Felling-axe.
Grease-tin.

2 Drag-ropes.
Swingletree.

1 Carbine.
Bill-hook.

Spade.

12, 2½ lb. cartridges; 2 funnels; 3 blue boxes, each containing 8 shrapnel fuzes; 1 knife; 1 mallet; 2 needles; 1 pair pincers; 1 saw set; 1 pair scissors; 2 setters; 1 oz. worsted; 1 set fuze borers; 2 straps for fuze boxes; 2 files.

12 shrapnel, in 2 tiers.
6 portfires, on lid.
1 copy of Instructions for fixing fuzes.
5 fuze sections.
2 drivers. 2 keys.

1 drag washer.
1 linchpin.
2 couples.

12, 2½ lb. cartridges.

1 black box, containing 10 common fuzes; 1 tube pocket; 100 friction tubes in tin box.

4 common shells 2 common case	lower tier.
4 common shells 2 common case	upper tier.

Spade.

Water-bucket.

Pickaxe.

Water-bucket.

TRAIL.

The stores on the gun-carriage are buckled on by Nos. 1, and 6.

2 portfire-sticks. 2 handspikes.

Spare sponge, and wadhook, underneath the trail.

The fitting-ropes are substituted for drag-ropes.

Sponge.

1 set priming-irons.

1 sponge head.

1 rammer head.

pincers.
wrench.
hammer.

claw-hammer.

2 punches.
2 common spikes.
1 spring ditto.
2 thumb-stalls.
1 spare tangent screw.

3 lb. slow match.

Camp-kettle.

Camp-kettle.

HOW.

24-POUNDER HOWITZER-AMMUNITION-WAGGON.

LIMBER.

Picket-line. Felling-axe.
Grease-tin.

Lifting-jack. Bill-hook.
Swingletree.

Spade.

12, 2½ lb. cartridges.

2 blue boxes each containing 8 shrapnel fuzes.

12 shrapnel, in 2 tiers.

6 portfires, on lid.

1 drag washer.
1 linchpin.
2 couples.

12 linchpin ties.

12, 2½ lb. cartridges.

1 black box containing 10 common fuzes.

1 tube pocket.

100 brass tubes.

4 common shells } lower
2 common case } tier.

4 common shells } upper
2 common case } tier.

Spade.

Water-bucket.

Pickaxe. Water-bucket.

The stores on the waggon limber are buckled on by Nos. 4, and 5. (Spare wheel.) The stores on the waggon body are buckled on by Nos. 2, 3, 7, 8.

10 sets of horse-shoes.

18, 2½ lb. cartridges.

2 blue bags, each containing 8 shrapnel fuzes.

18 shrapnel, in 2 tiers.

3½ lb. slow match.

10 sets of horse-shoes.

Tent-poles, picket-posts.
Hand-saw in leather case.

7 common shells } lower tier.
2 carcasses }

9 common shells, upper tier.

1 skein marline.

1 skein Hambro' line.

50 empty flannel cartridges.

2 black bags, each containing 10 common fuzes.

18, 2½ lb. cartridges.

Tent-poles, picket-posts.

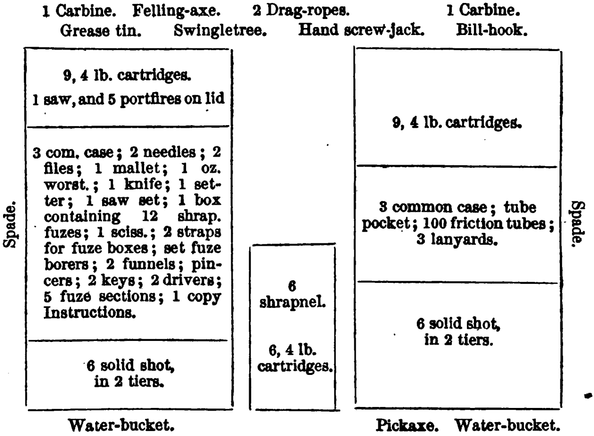
Camp-kettle, grease-mag., reaping-hooks, maul, camp-kettle.

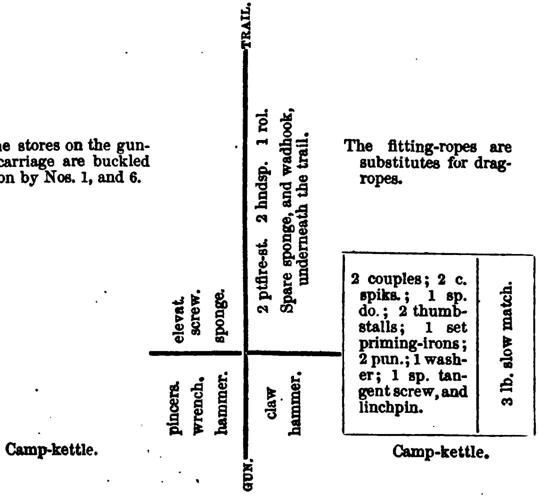
Tent-pegs, and tents on foot-boards. 10 sets horse-shoes.

Blankets, and corn sacks on limber-boxes.

12-POUNDER GUN.

LIMBER.


1 Carbine.
Felling-axe.
2 Drag-ropes.
1 Carbine.
Grease tin.
Swingletree.
Hand screw-jack.
Bill-hook.
9, 4 lb. cartridges.
1 saw, and 5 portfires on lid
3 com. case; 2 needles; 2 files; 1 mallet; 1 oz. worst.; 1 knife; 1 setter; 1 saw set; 1 box containing 12 shrap. fuzes; 1 sciss.; 2 straps for fuze boxes; set fuze borers; 2 funnels; pincers; 2 keys; 2 drivers; 5 fuze sections; 1 copy Instructions.
6 solid shot, in 2 tiers.
Spade.
6 shrapnel.
6, 4 lb. cartridges.
9, 4 lb. cartridges.
3 common case; tube pocket; 100 friction tubes; 3 lanyards.
6 solid shot, in 2 tiers.
Spade.
Water-bucket.
Pickaxe.
Water-bucket.


TRAIL.
2 ptfire-st. 2 hndsp. 1 rol.
Spare sponge, and wadhook, underneath the trail.
elevat. screw.
sponge.
pincers.
wrench.
hammer.
claw hammer.
GUN.
2 couples; 2 c. spiks.; 1 sp. do.; 2 thumbstalls; 1 set priming-irons; 2 pun.; 1 washer; 1 sp. tangent screw, and linchpin.
3 lb. slow match.
Camp-kettle.
Camp-kettle.

The stores on the gun-carriage are buckled on by Nos. 1, and 6.

The fitting-ropes are substitutes for drag-ropes.

12-POUNDER GUN-AMMUNITION WAGGON.

LIMBER.

Picket-line. Felling-axe.
Grease-tin.

Spade.

4 shrapnel (below). 1 sk. marline. 1 ditto Hambro' line. 1 blue box containing 12 shrapnel fuzes.	8, 4 lb. cartridges. 6 solid shot, (below).
	6 shrapnel. 8, 4 lb. cartridges. 5 portfires, on lid.

Water-bucket.

The stores on the waggon limber are buckled on by Nos. 4, and 5.

Lifting-jack. Bill-hook.
Swingletree.

8, 4 lb. cartridges. 6 solid shot.	Tube pocket.
8, 4 lb. cartridges. 6 solid shot.	4 common case.

Spade.

Pickaxe. Water-bucket.

The stores on the waggon body are buckled on by Nos. 2, 3, 7, 8.

(Spare wheel.)

10 sets of horse-shoes.

4 solid shot, (below). 4 shrapnel, (above). 50 empty flannel cartridges. A fuze box containing 12 shrap. fuzes.	12, 4 lb. cartridges. 8 solid shot.	12, 4 lb. cartridges. 8 shrapnel.

10 sets of horse-shoes.

Tent-poles, picket-posts.
Hand-saw in leather case.

12, 4 lb. cartridges. 8 solid shot, (below).	12, 4 lb. cartridges. 8 solid shot, (below).	Spare sponge head. Do. ramr. 5 lb. slow match. 8 solid shot, in 2 tiers.

Tent-poles, picket-posts.

Camp-kettle, grease-mag., reaping-hooks, maul, camp-kettle.
Tent-pegs and tents on foot-boards. 10 sets horse-shoes.
Blankets, and corn sacks on limber boxes.

32-POUNDER HOWITZER.

LIMBER.

1 Carbine. Felling-axe. Drag-ropes. 1 Carbine.
Grease-tin. Swingletree. Hand screw-jack. Bill-hook.

Spade.

2 shrapnel.
2, 3 lb. cartridges.

4 shrapnel.
4, 3 lb. cartridges.
5 portfires, and 1 saw on lid.

2 common case.
2, 3 lb. cartridges.

*
100 friction tubes.
3 lanyards. 2 funnels.
1 black box, containing 10 common fuzes.

2 common shells.
2, 3 lb. cartridges.

4 common shells.
4, 3 lb. cartridges.

Spade.

Water-bucket. Pickaxe. Water-bucket.

* This box should contain, in addition, the following stores :—

1 blue box containing 12 shrapnel fuzes; 1 knife; 1 mallet; 2 needles; 1 pincers; 1 saw set; 1 scissors; 2 setters; 1 oz. of worsted; set fuze borers; 2 straps for fuze boxes; 1 copy of Instructions for fixing fuzes; 5 fuze sections; 2 drivers; tube pocket; 2 files; 2 keys.

TRAIL.

The stores on the gun-carriage are buckled on by Nos. 1, and 6.

The fitting-ropes are substituted for drag-ropes.

Sponge.

2 portfire-sticks. 2 handspikes.

Spare sponge and wadhook underneath trail.

2 couples.
2 washers.
2 linchpins.
1 sponge head.
1 rammer head.
1 set priming-irons.

pincers. wrench. hammer.

claw-hammer.

3 lb. slow match.

2 punches.
1 spare tangent screw.
2 common spikes.
1 spring ditto.
2 thumb stalls.

Camp-kettle. Camp-kettle.

BOW.

32-POUNDER HOWITZER-AMMUNITION-WAGGON.

LIMBER.

Picket-line. Felling-axe. Lifting-jack. Bill-hook.
Grease-tin. Swingletree.

Spade.

1 skein of marline. 1 skein of Hambro' line. 6 shrapnel, in 2 tiers.	12, 3 lb. cartridges.	Blue box, containing 12 shrapnel fuzes. 6 shrapnel, in 2 tiers.	Black box containing 10 common fuzes. 6 common shells in 2 tiers.	12, 3 lb. cartridges.	Tube pocket, containing 25 brass tubes. 6 common shells, in 2 tiers.

Spade.

Water-bucket. Pickaxe. Water-bucket.

The stores on the waggon limber are buckled on by Nos. 4, and 5. (Spare wheel.) The stores on the waggon body are buckled on by Nos. 2, 3, 7, 8.

10 sets of horse-shoes.

1 bag, containing 12 shrapnel fuzes. 6 shrapnel, in 2 tiers.	9, 3 lb. cartridges. 6 shrapnel. 50 empty flannel cartridges.	6, 3 lb. cartridges. 2 common shells.

10 sets of horse-shoes.

Tent-poles, picket-posts.
Hand-saw, in leather case.

6, 3 lb. cartridges. 3 common shells.	9, 3 lb. cartridges. 6 common shells.	3 packets of common fuzes, 10 in each. 6 common shells, in 2 tiers.

Tent-poles, picket-posts.

Camp-kettle, grease-mag., reaping-hooks, maul, camp-kettle.

Tent-pegs and tents on foot-boards. 10 sets horse-shoes.

Blankets, and corn sacks on limber-boxes.

ORDNANCE, CARRIAGES, AND APPOINTMENTS.

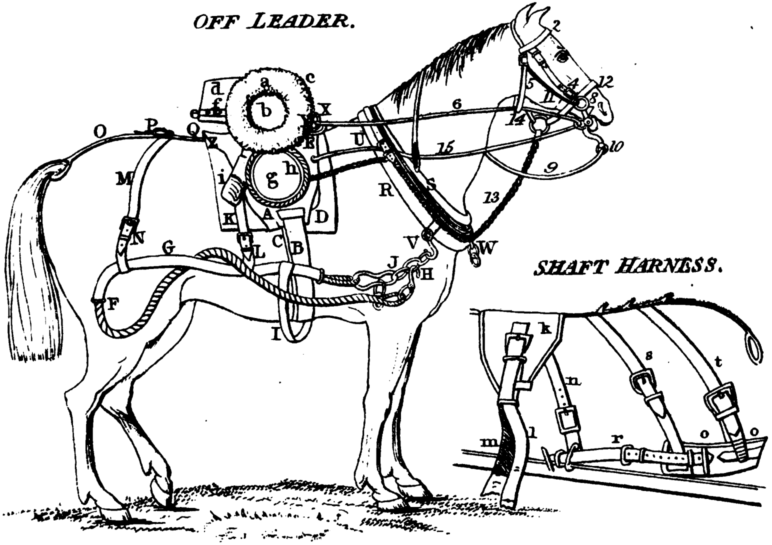
	12-pounder.			9-pounder.			24-pounder howitzer.			12-pounder howitzer.			Light 6-pounder.		
Gun, carriage, and limber.	39	2	15	33	1	23	32	3	3	24	2	7	23	3	11
Side-arms, intrenching tools, &c.	0	3	14	0	3	10	0	2	25	0	2	23	0	3	2
Ammunition, &c.	3	3	17	3	3	20	4	3	25	3	3	15	3	2	16
Total . .	44	1	18	38	0	25	38	1	25	29	0	17	27	1	1
Waggon - limber and body, including spare wheel.	19	1	14	19	0	26	17	0	25	17	0	25	18	2	26
Stores, intrenching tools, spare horse-shoes, &c.	4	0	7	4	0	7	4	0	7	4	0	7	4	0	7
Ammunition . .	11	3	26	10	3	16	12	0	5	10	1	9	10	2	8
Total . .	35	1	19	34	0	21	33	1	9	31	2	13	33	1	13

A 9-pounder with six horses can, without distressing the horses, march about four miles in an hour and a half, eight miles in four hours, and sixteen miles in ten hours.

WEIGHT OF RIDERS, HARNESS, &c., of a Field battery, equipped in marching order.

		st.	lb.
Lead . .	Near set of harness	5	8
	Driver, in marching order, including greatcoat .	11	0
	Total weight carried by riding horse. . .	16	8
	Off set of harness	6	8
Wheel .	Near set of harness	6	2
	Driver, in marching order, including greatcoat .	11	0
	Total weight carried by riding horse. .	17	2
	Off set of harness.	7	5
	Mounted N. C. officer's appointments	7	5
	Non-commissioned officer.	12	0
	Total weight carried by horse . . .	19	5

The average weight of an Artillery horse is 10 cwt. 2 qrs.



OFF LEADER.

SHAFT HARNESS.

OFF LEADER

A Pad or Off Saddle
B Surcingle
C Girth of the Pad
D Pannel of Dº
E Pad Staples
F Trace
G Pipe of Dº
H Hook of Dº
I Belly Band of Dº
J Trace Links
K Bearing Strap
L Buckling Piece of Dº
M Hip Strap
N Buckling Piece of Dº
O Crupper
P Crupper Ring
Q Buckling Piece of Crupper
R Collar
S The Hames
U The Housing Strap
V Shoulder Link & Hook
W Breast Chains or Links
X Wither Strap
Y Bearing Hook
Z Cantle of Pad
a Sheepskin
b Valise
c Baggage Strap
d Mess Tin
e Dº Strap
f Buckle of Dº
g Wooden Canteen
h Forage Cord
i Nose Bag

THE BRIDLE.

2 Front or Brow Band
3 Cheek
4 Cheek Billets
5 Throat Lash
6 Bearing Rein
7 Bit
8 Cheek of Dº
9 Leading Rein
10 Bar of the Bit
11 Head Collar
12 Nose Band
13 Collar Chain
14 Jowl Strap. 15 Side Rein

SHAFT HARNESS.

k Pad or off Saddle
l Back Band
m Shaft Tugs
n Bearing Strap
o Breeching
r Strap of Breeching
s Loin Strap
t Hip Strap

DETAIL OF A 9-POUNDER BATTERY, ROYAL HORSE ARTILLERY.—WAR ESTABLISHMENT.

Number of Carriages.	EQUIPMENT.	Men.			Horses.			Sets of Appointments N. C. Officers and Men.	Harness Sets Double.	
		Gunners.	Drivers.	Total.	Riding.	Draught.	Total.		Lead.	Wheel.
4	9-Pounder Guns	40	16	56	40	32	72	40	12	4
2	24-Pounder Howitzers	20	8	28	20	16	36	20	6	2
6	Gun Ammunition Waggons	12	18	30	4	36	40	4	12	6
5	Howitzer Ammunition Waggons	10	15	25	2	30	32	2	10	5
1	Store Limber Waggon	.	3	3	.	6	6	.	2	1
1	Spare Gun Carriage	.	3	3	.	6	6	.	2	1
1	Forge	.	3	3	.	6	6	.	2	1
1	Rocket Carriage	.	4	4	.	8	8	.	3	1
1	Store Cart	.	1	1	.	2	2	.	.	1
1	Medicine Cart	.	1	1	.	2	2	.	.	1
2	Light Forage Waggons	.	4	4	.	8	8	.	2	2
3	Water Carts	.	3	3	.	6	6	.	.	3
.	For 2 Staff Serjeants, 2 Trumpeters, 1 Farrier, 3 Shoeing-Smiths	.	.	.	8	.	8	8	.	.
.	Spare Men, Officers' Servants and Bâtmen, &c., and Spare Horses	15	44	59	6	16	22	.	4	4
.	Officers' Horses	.	.	.	12	.	12	.	.	.
.	Bât Horses	.	.	.	.	6	6	.	.	.
28	Total Carriages. Total	97	123	220	92	180	272	74	55	32

Officers.	Captain	1
	Second Captain	1
	Lieutenants	3
	Assist.-Surgeon	1
Non-Commissioned Officers, and Men.	Staff Serjeants	2
	Serjeants	8
	Corporals	4
	Bombardiers	6
	Gunners	97
	Drivers	123
	Trumpeter	1
Artificers.	Farrier	1
	Shoeing-smiths	6
	Collar-makers	3
	Wheelers	2
	Total	259

DETAIL OF AN 18-POUNDER FIELD BATTERY, ROYAL ARTILLERY.—WAR ESTABLISHMENT.

Number of Carriages.	EQUIPMENT.	Men.			Horses.			Sets of Appointments.		Harness Sets Double.	
		Gunners and Drivers.		Total.	Riding.	Draught.	Total.	Officers.	N.C. Officers.	Lead.	Wheel.
4	18-Pounder Guns	56	24	80	.	48	48	.	.	16	8
12	Gun Ammunition Waggons	24	36	60	.	72	72	.	.	24	12
2	Store Limber Waggons	.	6	6	.	12	12	.	.	4	2
1	Spare Gun Carriage	.	4	4	.	8	8	.	.	2	2
1	Platform Waggon	.	4	4	.	8	8	.	.	2	2
1	Forge	.	3	3	.	6	6	.	.	2	1
1	Store Cart	.	1	1	.	2	2	.	.	.	1
1	Medicine Cart	.	1	1	.	2	2	.	.	.	1
2	Light Forage Waggons	.	4	4	.	8	8	.	.	2	2
3	Water Carts	.	3	3	.	6	6	.	.	.	3
	For Staff-Serjeants, and Non-Commissioned Officers	.	.	.	10	.	10	.	10	.	.
.	For Trumpeters	.	.	.	2	.	2	.	2	.	.
	For Farrier	.	.	.	1	.	1	.	1	.	.
	For Shoeing-smith	.	.	.	1	.	1	.	1	.	.
.	Spare Men, Officers' Servants and Bâtmen, &c., and Spare Horses	15	24	39	2	20	22	.	1	3	3
.	Officers' Horses	.	.	.	6	.	6	6	.	.	.
.	Bât Horses	.	.	.	.	6	6	.	.	.	.
28	Total Carriages. Total	95	110	205	22	198	220	6	15	55	37

Officers.	Captain	1
	Second Captain	1
	Lieutenants	3
	Assist.-Surgeon	1
Non-Commissioned Officers, and Men.	Staff-Serjeants	2
	Serjeants	7
	Corporals	5
	Bombardiers	6
	Gunners Drivers	205
	Trumpeters	2
Artificers.	Farrier	1
	Shoeing-smiths	6
	Collar-makers	3
	Wheelers	2
	Total	245

DETAIL OF A 9-POUNDER FIELD BATTERY, ROYAL ARTILLERY.—WAR ESTABLISHMENT.

Number of Carriages.	EQUIPMENT.	Men.			Horses.			Sets of Appointments.		Harness Sets Double.	
		Gunners and Drivers.		Total.	Riding.	Draught.	Total.	Officers.	N.C. Officers.	Lead.	Wheel.
4	9-Pounder Guns	40	16	56	.	32	32	.	.	12	4
2	24-Pounder Howitzers	20	8	28	.	16	16	.	.	6	2
6	Gun Ammunition Waggons	12	18	30	.	36	36	.	.	12	6
5	Howitzer Ammunition Waggons	10	15	25	.	30	30	.	.	10	5
1	Store Limber Waggon	.	3	3	.	6	6	.	.	2	1
1	Spare Gun Carriage	.	3	3	.	6	6	.	.	2	1
1	Forge	.	3	3	.	6	6	.	.	2	1
1	Rocket Carriage	.	4	4	.	8	8	.	.	3	1
1	Store Cart	.	1	1	.	2	2	.	.	.	1
1	Medicine Cart	.	1	1	.	2	2	.	.	.	1
2	Light Forage Waggons	.	4	4	.	8	8	.	.	2	2
3	Water Carts	.	3	3	.	6	6	.	.	.	3
.	For Staff-Serjeants, and mounted Non-Com. Officers	.	.	.	14	.	14	.	14	.	.
	Trumpeters	.	.	.	2	.	2	.	2	.	.
	Farrier	.	.	.	1	.	1	.	1	.	.
	Shoeing-smiths	.	.	.	1	.	1	.	1	.	.
.	Spare Men, Officers' Servants and Bâtmen, &c., and Spare Horses	15	24	39	2	20	22	.	1	3	3
.	Officers' Horses	.	.	.	6	.	6	6	.	.	.
.	Bât Horses	.	.	.	.	6	6	.	.	.	.
28	Total Carriages. Total	97	103	200	26	184	210	6	19	54	31

Officers.	Captain	1
	Second Captain	1
	Lieutenants	3
	Assist.-Surgeon	1
Non-Commissioned Officers, and Men.	Staff-Serjeants	2
	Serjeants	8
	Corporals	5
	Bombardiers	7
	Gunners Drivers	200
	Trumpeters	2
Artificers.	Farrier	1
	Shoeing-smiths	6
	Collar-makers	3
	Wheelers	2
	Total	242

DETAIL OF A 32-POUNDER HOWITZER FIELD BATTERY, ROYAL ARTILLERY.—WAR ESTABLISHMENT.

Number of Carriages.	EQUIPMENT.	Men.			Horses.			Sets of Appointments.		Harness Sets Double.	
		Gunners and Drivers.	Drivers.	Total.	Riding.	Draught.	Total.	Officers.	N.C.Officers.	Lead.	Wheel.
4	32-Pounder Howitzers	48	16	64	.	32	32	.	.	12	4
12	Howitzer Ammunition Waggons	24	36	60	.	72	72	.	.	24	12
1	Store Limber Waggon	.	3	3	.	6	6	.	.	2	1
1	Spare Howitzer Carriage	.	4	4	.	8	8	.	.	3	1
1	Forge	.	3	3	.	6	6	.	.	2	1
1	Store Cart	.	1	1	.	2	2	.	.	.	1
1	Medicine Cart	.	1	1	.	2	2	.	.	.	1
2	Flanders Waggons	.	4	4	.	8	8	.	.	2	2
3	Water Carts	.	3	3	.	6	6	.	.	.	3
	For Staff Serjeants, and Mounted Non-Com. Officers	.	.	.	10	.	10	.	10	.	.
.	Trumpeters	.	.	.	2	.	2	.	2	.	.
	Farrier	.	.	.	1	.	1	.	1	.	.
	Shoeing-smith	.	.	.	1	.	1	.	1	.	.
.	Spare Men, Officers' Servants and Bâtmen, &c., and Spare Horses	15	24	39	2	20	22	.	1	3	3
.	Officers' Horses	.	.	.	6	.	6	6	.	.	.
.	Bât Horses	.	.	.	.	6	6	.	.	.	.
26	Total Carriages. Total	87	95	182	22	168	190	6	15	48	29

Officers.	Captain	1
	Second Captain	1
	Lieutenants	3
	Assist.-Surgeon	1
Non-Commissioned Officers, and Men.	Staff-Serjeants	2
	Serjeants	6
	Corporals	5
	Bombardiers	6
	Gunners Drivers	182
	Trumpeters	2
Artificers.	Farrier	1
	Shoeing-smiths	5
	Collar-makers	2
	Wheelers	2
	Total	219

DETAIL OF A 9-POUNDER BATTERY, ROYAL HORSE ARTILLERY.—HOME ESTABLISHMENT.

Number of Carriages.	EQUIPMENT.	Men.			Horses.			Sets of Appointments N.C. Officers and Men.	Harness Sets Double.	
		Gunners.	Drivers.	Total.	Riding.	Draught.	Total.		Lead.	Wheel.
4	9-Pounder Guns	40	16	56	40	32	72	40	12	4
2	24-Pounder Howitzers	20	8	28	20	16	36	20	6	2
4	Gun Ammunition Waggons	8	8	16	.	16	16	.	4	4
2	Howitzer Ammunition Waggons	4	4	8	.	8	8	.	2	2
1	12-Pounder Rocket Carriage	2	3	5	.	6	6	.	2	1
1	Store Limber Waggon	.	2	2	.	4	4	.	1	1
1	Forge	.	2	2	.	4	4	.	1	1
1	Store Cart	.	1	1	.	2	2	.	.	1
1	Hospital Cart	.	1	1	.	2	2	.	.	1
1	Light Forage Waggon	.	2	2	.	4	4	.	1	1
.	For 2 Staff Serjeants, 1 Trumpeter, 1 Farrier, and 3 Shoeing Smiths	.	.	.	7	.	7	7	.	.
.	Spare Men, Officers' Servants and Bâtmen, and Spare Horses	16	38	54	7	12	19	7	5	1
18	Total Carriages. Total	90	85	175	74	106	180	74	34	19

Officers.	Captain	1
	Second Captain	1
	Lieutenants	3
	Assist.-Surgeon	1
Non-Commissioned Officers, and Men.	Staff Serjeants	2
	Serjeants	8
	Corporals	6
	Bombardiers	9
	Gunners	90
	Drivers	85
	Trumpeter	1
Artificers.	Farrier	1
	Shoeing-smiths	6
	Collar-makers	3
	Wheelers	3
	Total	220

DETAIL OF A 6-POUNDER BATTERY, ROYAL HORSE ARTILLERY.—HOME ESTABLISHMENT.

Number of Carriages.	EQUIPMENT.	Men.			Horses.			Sets of Appointments N. C. Officers and Men.	Harness Sets Double.	
		Gunners.	Drivers.	Total.	Riding.	Draught.	Total.		Lead.	Wheel.
4	6-Pounder Guns	32	12	44	32	24	56	32	8	4
2	12-Pounder Howitzers	16	6	22	16	12	28	16	4	2
4	Gun Ammunition Waggons	8	8	16	.	16	16	.	4	4
2	Howitzer Ammunition Waggons	4	4	8	.	8	8	.	2	2
1	6-Pounder Rocket Carriage	2	3	5	.	6	6	.	2	1
1	Store Limber Waggon	.	2	2	.	4	4	.	1	1
1	Forge	.	2	2	.	4	4	.	1	1
1	Store Cart	.	1	1	.	2	2	.	.	1
1	Hospital Cart	.	1	1	.	2	2	.	.	1
1	Light Forage Waggon	.	2	2	.	4	4	.	1	1
.	For 2 Staff Serjeants, 1 Trumpeter, 1 Farrier, and 3 Shoeing Smiths	.	.	.	7	.	7	7	.	.
.	Spare Men, Officers' Servants and Bâtmen, &c., and Spare Horses	18	29	47	5	8	13	5	2	2
18	Total Carriages. Total	80	70	150	60	90	150	60	25	20

Officers.	Captain	1
	Second Captain	1
	Lieutenants	3
	Assist.-Surgeon	1
Non-Commissioned Officers, and Men.	Staff-Serjeants	2
	Serjeants	8
	Corporals	6
	Bombardiers	9
	Gunners	80
	Drivers	70
	Trumpeters	1
Artificers.	Farrier	1
	Shoeing-smiths	6
	Collar-makers	3
	Wheelers	3
	Total	195

DISTRIBUTION OF A 9-POUNDER FIELD BATTERY, ROYAL ARTILLERY.—HOME ESTABLISHMENT.

		Sub-divisions. 1	2	3	4	5	6	Total.
Carriages	9-Pr. Guns	1	1	..	..	1	1	4
	24-Pr. Howitzers	..	..	1	1	..	..	2
	9-Pr. Ammunition Waggons	1	1	..	..	1	1	4
	24-Pr. Ammunition Waggons	..	..	1	1	..	..	2
	Store Limber Waggons	..	..	..	..	1	..	1
	Forge	..	1	..	..	..	..	1
	Store Cart	1	..	..	..	..	..	1
	Hospital Cart	..	..	1	..	..	..	1
	Light Forage Waggons	..	..	..	..	..	1	1
	Total	3	3	3	2	3	3	17
Horses	Riding	5	3	3	2	3	4	20
	Draught	14	14	14	14	14	14	84
	Total	19	17	17	16	17	18	104
Saddles	Officers	1	1	1	1	1	1	6
	Non-Com. Officers	2	2	2	1	2	2	11
	Trumpeters	1	..	..	..	..	..	1
	Farriers	1	..	..	..	..	..	1
	Shoeing-Smiths	..	..	..	..	..	1	1
	Total	5	3	3	2	3	4	20
Harness	Lead	3	4	3	3	4	4	21
	Wheel	3	3	3	2	3	3	17
	Spare Lead	..	..	1	1	..	..	2
	Spare Wheel	1	..	..	1	..	..	2
	Total	7	7	7	7	7	7	42
Short Traces, pairs		1	1	1	1	1	1	6
Lounging Articles, set		1	..	..	..	..	..	1
Officers, N. C. Officers, Artificers, and Men.	1st Captain	1	..	..	..	..	..	1
	2nd Captain	..	..	..	..	1	..	1
	Lieutenants	..	1	..	1	..	1	3
	Assistant-Surgeon	..	..	1	..	..	..	1
	Staff-Serjeants	1	..	..	..	..	1	2
	Serjeants	2	1	1	1	1	2	8
	Corporals	1	1	1	1	1	1	6
	Bombardiers	1	2	1	2	1	2	9
	Gunners	17	16	17	16	17	17	100
	Drivers	12	13	12	13	13	12	75
	Trumpeters	1	..	..	..	1	..	2
	Farriers	1	..	..	..	..	..	1
	Shoeing-Smiths	1	1	1	1	1	1	6
	Wheelers	..	..	1	..	1	..	2
	Collar-Makers	..	1	..	1	..	1	3
	Total	38	36	35	36	36	38	220

ON THE INTERIOR MANAGEMENT OF A BATTERY.

(*Vide* "Field Battery Exercise.")

1. The greatest care should be paid to the fittings of the saddles and collars; extensive sore backs, and galled shoulders arise chiefly from neglect on the march: and by prompt attention on the part of the officers, many horses may be preserved to the service, which would otherwise be disabled for months. The drivers should never be suffered to lounge in their saddles, or to sit uneven. A folded blanket under the saddle is found to be the best preventive of sore backs, as it adapts the shape of the saddle to any loss of flesh in the animal.

On long marches, the shaft horse should invariably be provided with a half blanket under the pad saddle; every driver should also have attached to his harness a pair of pads of basil leather, about six inches by four, stuffed with hair; and the moment any tenderness is perceived in a horse's shoulder, the pressure should be relieved by placing the pads above and below the tender part.

2. On a march, there will always be an advanced, and rear guard; the advanced guard of one day becoming the rear guard of the next. On arriving on the ground where the battery is to be parked, the advanced guard will immediately pitch their tent, and post sentinels. When the battery quits its ground, the non-commissioned officer of the guard is responsible that nothing be left behind.

3. When a battery is to march, the camp-kettles, and everything that will not be required before morning, should be lashed on the carriages at sunset.

4. In parking guns, the usual interval is ten or twelve paces; but on a march, that everything may be better under the eye of the sentinels, the intervals may be diminished to three or four paces. The guns are to be in the first line, covered by their respective waggons; the spare ammunition, and store carriages in the third line. The tents of the detachment are sometimes on the flanks of the battery, and sometimes in rear of their respective sub-divisions; the officers in rear of the battery. The horses are sometimes picketed in rear of the whole, and parallel to the line of guns, and sometimes perpendicular to this line, and on the flanks between the detachments, tents, and the carriages; but in general, the form of encamping will depend on the nature of the ground, and local circumstances. In every situation the approach to the park, and the road by which the guns are brought out, should be kept clear and open.

5. If the battery is parked in hot weather, the naves of the wheels must be defended as much as possible from the effect of the sun, by sods, or other covering.

6. When a battery arrives in camp, quarters, or cantonments, each non-commissioned officer will immediately examine every part of the carriages of his sub-division, especially the wheels, to the greasing of which he will attend. Any damages, to be repaired without delay;

he will report to the officer of his division, who will report to the commander of the battery.

7. When a battery is in stationary quarters, there must be a weekly inspection of every part of the battery, and a parade in marching order, when circumstances will permit; at which parade, every part of the harness and appointments of gunners and drivers is expected to be in the best order. Particular attention should be paid to the state of the ammunition, which should be frequently aired; and no fresh ammunition should ever be received without being gauged to the guns.

8. The drivers must immediately report any loss, or breakage of their harness; and, on the instant, make known to the non-commissioned officer of the sub-division, any gall, or other hurt which may have happened to the horses committed to their charge: any neglect on this point must be punished. Airing, and beating with a knotted rope the stuffing of the collars and saddles, is an important part of the driver's duty, which should never be omitted on continued marches. In camp, greasy heels are the most common disability which horses labour under; and as they proceed from cold, occasioning humours to settle, the best preventive is hand-rubbing, and exercise, to keep up a circulation.

9. Unless for some particular purpose, the elevating screws should never be raised higher than the half of their length; on a march, they should be covered with a piece of canvas, or an old flannel cartridge, which will prevent their being clogged with dirt; and the travelling chain should be always applied. The pintail, and the trail plate eye, should be greased previous to marching.

10. After a field day, or an action, the bores of the guns should be washed, and then laid under metal.

11. If a wheel be so disabled as not to be worth repairing, the nave, if not damaged, should be at any rate saved. If the nave be good, a new wheel can easily be made from materials perhaps found on the spot, but it is very difficult to find a nave.

12. In marching in ordinary circumstances, the officer next for duty will always proceed in advance, to take up quarters, and to choose ground for parking, or encamping on; and the officer on duty for the day will always march in, and bring up the rear.

13. When a battery is to march, and "*Boot and saddle*" has been sounded, the officer of the day, the non-commissioned officers, drivers, and horses will turn out, and immediately proceed to the park and put-to; if encamped, tents to be struck, and lashed to the carriages. At the sound "*Turn out,*" the whole of the officers, non-commissioned officers, and gunners, repair to the park; and when the usual inspections have been made, and the regular reports delivered to the commander, the battery will be marched off.

14. Feeding will always take place three times a day at the park, under the inspection of the officer of the day; when the nose-bags have been filled by the non-commissioned officer in charge of the forage, the trumpeter is to sound "*Feed,*" the nose-bags are put on,

and the drivers fall in, in front; after the feed, the nose-bags are rolled up, and buckled on.

15. A non-commissioned officer is to have charge of, and serve out the corn, and forage, which for security will be deposited at the park guard; but on a march, when the corn is carried on the ammunition waggons, no more corn should be taken off the carriages than is likely to be wanted.

16. Buckets are provided for watering the horses on a march; by this means they can be watered from wells, or places inaccessible to the animals, or at least to more than one or two of them at a time; but the operation is a long one. If on a march a small river or stream of water is to be forded, this opportunity of watering them, or at any rate of giving them a mouthful of water in crossing it, should be seized: it saves much time. Should the stream, however, be very rapid, or deep, or should there be troops immediately in the rear, no halt should be made in fording it.

17. The *Serjeant-major* is to superintend all parades, and drills, under the inspection of the officer on duty. The *Quartermaster-serjeant* is to draw provisions, and forage; he is to make out returns, and have charge of the spare stores.

18. The *Trumpeter* is always to be quartered in the nearest billet to the commanding officer; and the men, and horses of each sub-division, and division to be as near together as possible. A gunner from each sub-division, or a gunner of the guard, is to be made acquainted with the quarters of the commander of the battery, that in any emergency there may be no delay in finding him out; the same applies to the officers of divisions as far as their divisions are concerned.

19. The *Farrier* is to report every evening to the commanding officer the state of the sick animals; and on the ——, (the particular days to be mentioned) a return, in writing, of the number of horse (and mule, if any) shoes, and quantity of horse medicines expended.

20. The senior *Collar-maker*, the *Jobbing-smith*, and the *Wheeler*, to make similar reports of the stores expended in their several departments; these reports to be delivered to the serjeant-major, to be laid by him before the commander of the battery.

21. The *Artificers* are to work as near as possible to the park guard, the non-commissioned officer of which is responsible that no work is done, or horse shod, except for the battery, without written permission from the commander.

22. The *Forge*, when employed, should be removed to a proper distance from the park. It should, at night, be brought back to its place, and everything arranged on it, so that, should the battery be suddenly ordered to march, there may be no delay.

LASSO.

Lasso harness consists of a brown leather surcingle, and one trace. The surcingle is rather wider than a common girth, and is composed of two pieces (joined together by rings), one of which is placed over the saddle, and the other round the belly of the horse. There are also rings at the end of the surcingle, which is drawn very firmly round the horse, and fastened tight by lapping a white leather thong (fixed at one end of the surcingle) through these rings. There are two descriptions of traces, one being 8, and the other 12 feet long. They have hooks at each end, and, when the lasso harness is made use of by cavalry, &c., to assist draught horses in moving very heavy carriages, or in dragging guns, &c., up steep hills, one of these hooks is fastened to a ring in the surcingle, and the other to the carriage, &c.

Lasso harness may be advantageously employed with all horses; even those unaccustomed to draught having been found perfectly tractable, and efficient the first time they were required to draw by means of the lasso. When two horses are in draught, the traces must be inside, and each rider should keep his horse's croup a little outwards.

EMBARKING, AND DISEMBARKING.

The following directions will be found applicable to nearly all the cases likely to occur: such as embarking, or disembarking from a beach; from a wharf; with, or without boats; in presence of an enemy, &c., &c. (*Vide* "Field Battery Exercise.")

Sec. 39. *Embarking Guns, and Carriages.*

Preparations.

1. On the arrival of the battery at the place of embarkation, it is to be drawn up in as compact order as is consistent with the performance of the operations required. The horses are to be taken out; the harness taken off, and packed in vats, and the stores in cases. When there are no vats and cases, the stores must be secured to the carriages, or tied together: the intrenching tools may remain with the carriages. The non-commissioned officers in charge of subdivisions will attach to their harness, and stores, pieces of basil having the number of their sub-divisions written upon them. The harness for each carriage should be embarked with it.

2. The gun detachments will prepare the carriages for embarkation. They will take off the side arms, and secure them together, take out the elevating screws, unkey the cap-squares, unlash the ammunition boxes, and coil up the lashing ropes. Each carriage, when called for, is to be run forward to the boat, or crane; the gun is to be unlimbered, and dismounted; the ammunition boxes, shafts, wheels, &c., to be taken off; the washers, and linch-pins must be carefully put away in the slow match box, and in the small box between the limber

boxes. Every article must be stowed away with the greatest care, and arranged so as to be got at without delay.

3. Those articles, which will be the last required when disembarking, are the first to be embarked. The divisions, and everything belonging to them, should be kept together as much as possible. The first to be embarked are the spare carriages, and forge, which are to be stowed forward, the left division next to them, and before the main hatchway; the centre abaft the hatchway; the right under the hatchway. The whole of the guns are put together, generally in the bottom of the hold, vents turned downwards, and a fid in them, to prevent their being choked.

4. When a battery is embarked in different vessels, every part should be complete, and a proportion of general stores be on board of each. If the voyage is likely to last some days, the cartouches with the ammunition must be taken out of the boxes, and stowed in the magazine. The ammunition must be so placed that whatever part belongs to any particular carriage may be got at without difficulty. When the cartouches are not taken out, the boxes must be stowed well aft in the hold, or between decks, and they should be well covered with wadmilltilts, or hair cloths.

5. In embarking from a beach, it may be necessary to erect small sheers, made of a couple of top gallant masts, previously prepared for the purpose. In embarking from a wharf, if there are cranes, they should be made use of. If boats are employed, the loads must be regulated by the state of the weather, and distance of the vessels.

Embarking the Horses.

6. When the vessels can come alongside a wharf, the horses are hoisted in by means of tackle. The slings, made of canvas, should be minutely inspected, to see that they are secure. There must be a double guy made fast to the horse's head, one end on shore, the other on board, to keep his head steady. A shoeing smith should be in each ship, to receive the horses.

7. A horse requires at least four men besides the driver to sling him, one on each side, one at his breast, and one behind. One end of the sling is passed under his belly, and both ends made to meet over his back; one man passes his loop through the other, it is received by the man on the other side, who hauls it through, hooking the tackle to it, both men holding up the ends of the sling. The men at the breast, and behind bring their ropes round, and make them fast to the grummets. The driver holds the horse's head, and makes fast the guys to it. The horse being previously blindfolded, the word "HOIST AWAY" is given, and he is hoisted on board. The sling is then taken off, and he is led to his place; the first horses being always placed forward, or aft, as the ship fills; the stalls nearest the hatchway being reserved for the horses which are to be first landed.

8. The horses are to be embarked in the same order as the carriages, taking care that the officers' and non-commissioned officers' horses are

on board with the divisions to which they belong. The farriers and shoeing-smiths should be distributed in different ships.

9. When horses are embarked in boats; sheers, or a derrick, are necessary. The head of the derrick must incline inwards when the horse is rising, but when he is high enough the head of the derrick or sheers must be forced out, to bring the horse over the boat. This applies to a beach, or wharf. Sand or straw should be put in the boats, to prevent the horses slipping. They should stand athwart, the head of one horse being on the starboard, and the head of the next on the larboard side. The drivers sit on the gunwale, or stand between the horses.

10. When horses are embarked from an open beach without any appliances, they are to be led to the boat, and the halter given to one of the men in it. The horse must then be made to walk or leap into it, the gunwale of the boat being inclined towards the shore. A quiet horse should first be embarked, and the others will more readily follow.

11. In embarking in presence of an enemy, the horses and carriages, should first be embarked, the guns being retained to the last, to repel any attack. If the position be a mile or two from the place of embarkation, it may be necessary to retain a portion of the horses.

APPLICATION OF FIELD ARTILLERY.*

General remarks.

1. In a defensive position, the guns of the largest calibre should be posted on the weakest points of the line, and on those from whence the enemy can be discovered at the greatest distance. Those heights on which the enemy in advancing may rest his flanks, and those from whence he may be fired upon obliquely, must also be occupied by the largest calibres.

2. In an offensive position, the guns of the heaviest calibre should be placed in such situations as will render them available, without difficulty, for any operations in advance. In heavy ground, a nine, or twelve pounder battery, when coming into action, should reverse, when it will be only necessary to drop the trail, instead of carrying it round by hand.

3. The guns should be placed as much as possible under cover; this is easily done on heights, by keeping them so far back that the muzzles are only to be seen over them. By proper attention, advantage may be taken of many situations, such as banks, ditches, &c.

4. Artillery in the field should be concealed from the enemy till the very moment it is to open; the guns may be masked by being a little retired, or by being covered with troops, particularly by cavalry.

Ammunition waggons.

5. No positive rule can be laid down for all cases, with respect

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* From "Field Battery Exercise," &c.

to the ammunition waggons in presence of an enemy: this must depend on a variety of circumstances; but in general it will be found expedient to place them under charge of an officer, who will conform to the movements of the main body, in such a manner and at such distance, as to enable him to supply the guns with ammunition, before that which is in the limbers is expended.

6. The spot selected for a battery should be one which does not present any obstacles to the ulterior movements.

7. The most elevated situations are not the best; the greatest effect may be produced at a distance of six hundred yards, from a height of thirty or forty yards; and at two hundred yards distance from a height of sixteen.

8. Round shot should be used from three hundred yards, upwards. The use of case should begin at three hundred, and the quickness of fire increase as the range diminishes.

9. Double charges of case may be used at one hundred and fifty or one hundred and sixty yards. Shrapnel shells should not be used at a less range than six hundred and fifty yards.

10. The guns should never be abandoned till the last extremity; the last discharges are the most destructive.

On the march.

1. Intelligent non-commissioned officers should be sent to reconnoitre a road or ground that artillery is to pass over, and, when necessary, to report the state of it. When the march is connected with military operations, an officer should always be employed for this duty.

2. The officers of divisions should frequently halt, to see that their carriages are marching in proper order, and are well up.

3. The strictest attention should constantly be paid to the correct preservation of distances, the loss of which may be made up by small bodies of artillery; but when in large bodies, or when acting with infantry, the operation is attended with serious disadvantage, particularly to the latter; it is a point, therefore, which cannot be too strongly insisted upon, being one of most essential consequence.

Advanced Guard.

4. A battery marching by itself should always have an advanced guard. In a narrow road it should be considerably in front, to stop all carriages which might cause obstruction. In a hilly road, it should reconnoitre the top of every hill, and see that it is all clear before the guns come up.

5. Parties should always be sent out on each flank.

6. When an accident happens to a carriage, either on the march, or manœuvring, those in its rear should pass it on the most convenient flank, and fill up its interval. It will resume its place as soon as the damage is repaired. A waggon belonging to a disabled gun should always remain with it; but a gun must not wait for its disabled

waggon, but leave only a sufficient number of men to put it into a proper state.

Crossing fords.

1. Artillery can cross a river about three and a half feet deep, though much depends on the strength of the current. The ammunition boxes are so well made that the water will seldom penetrate through them, particularly if the river be narrow, and the guns pass quickly. The canvas cartouches afford additional protection, and they may be taken out if necessary.

2. When the water is deep, and the current strong, great attention must be paid in fording. The person conducting the column over a direct ford should keep his eye steadily on an object on the opposite bank, which points out where the ford is: he must never look at the stream, which would deceive him, and would appear to carry him down, and he would endeavour to keep too high up the stream, and miss the ford.

3. All those in the rear should keep their eyes on those in front; every individual should wade rather against the stream, in order to resist its power.

4. Troops should always cross a ford with the largest possible front, for the same reason.

5. If the ford is not well known, and there is no guide, it should be previously examined, and the dangerous places marked. In fording, the horses should neither be allowed to trot, halt, or drink.

Passage of military bridges.

1. Great attention and caution are required in passing over pontoon bridges, the vibratory motion of which is very dangerous, and should be lessened by every possible means.

2. The troops, in passing, should not preserve an equal pace. There should be no halt on the bridge. As soon as the bridge is perceived to rock, the passage of the troops must be stopped.

3. The greatest precaution is necessary to prevent accidents in tide rivers at low water. Unless battens are nailed across the chesses on the slopes, the horses will have the greatest difficulty in keeping their feet, indeed if the chesses be wet it will be impossible; the men must therefore always assist; holding on when going down, and manning the wheels when going up.

4. The drivers must in some cases dismount, and an interval must be left between the carriages equal to their own length; they must be passed over gently. In wet weather over chesses, great care must be taken to prevent the horses slipping. It may sometimes be necessary, unless the bridge be strong, to pass the carriages and horses over separately.

5. In passing over a flying bridge, it may occasionally be advisable to take the horses out; and in boisterous weather, or at night, the wheels should be locked.

Crossing a bridge, and passing a defile.

1. The battery should always pass with the largest front possible.

2. The artillery must be previously posted to the right, and left of the bridge; if it be flat, and that the other side can be seen, a gun or two should be placed on each side, and close to the road leading to it; these guns should cross first, and come into action on the other side, the remaining guns continue in action, and follow by degrees; they should be posted at such a distance from the bridge, that they may keep up a fire while the others are crossing, and forming.

Advancing through a defile.

3. A defile should be passed as quickly as possible, as it is a much more hazardous operation than crossing a bridge. Artillery can seldom be made available till it has passed the defile; whereas it can generally be employed in clearing the opposite bank of a river, previous to the troops pushing across.

Over a bridge.

4. In retreating over a bridge, the artillery will gradually close in from the flanks of the troops, till all the guns are in line in front of the bridge. They will cross by degrees; the flank guns will generally cross under the protection of the centre ones; they may retire limbered up, taking up their position and coming into action to the right, and left of the bridge, to protect the centre guns, which will retire with the prolonge, and with the largest front possible. They may halt on the highest part, or middle of the bridge, and keep the enemy in check.

Retiring through a defile.

5. A battery should retire from one of its flanks under the protection of the other; the covering guns retiring with the largest front possible.

6. Should the defile be wide, and there are any favourable situations in it, they should be taken advantage of, and guns posted to protect the retreat of the others. The situations must be such as the guns can retire from, and continue the retreat without difficulty.

7. When artillery is retiring along a road, or through a defile which is hilly, some of the guns should halt on the tops of the hills, and protect the retreat of those in the hollow. In these cases, round shot may be fired with safety to the troops retreating, and perhaps with good effect against an enemy.

8. The guns which are retreating, may pass those in position without halting; they will take up other positions, the whole retreating alternately.

9. In retreating towards a defile, the artillery may retire in line, or by half batteries, or by divisions; forming new lines and retreating again; or it may retreat alternately; or in echellon from either flank. This must depend on the nature of the ground, and the flank on which the enemy may be.

10. In these retrograde movements, the ammunition waggons must be sent to the rear. One or two may be kept nearer than the others, to supply ammunition.

Artillery, acting with other troops.

1. The artillery should always cover the troops when advancing, retiring, or deploying into line.

2. When the line retires by alternate companies, wings, or battalions, the artillery must remain with that part of it which is nearest the enemy; retiring with the prolonge, and halting when it arrives at the halted part of the line.

In column.

3. When the troops are in column, the artillery should be on the flank.

4. When a line of troops wheels backward into column, the artillery break into column, and close to the reverse flank, so as not to interrupt the line of pivots.

ENCAMPING, AND PICKETING.

* *Sec.* 29. *First method.*

The battery being formed in line, at full intervals, the horses are picketed, and the tents pitched in rear.

Prepare to encamp, and picket.

At the word PREPARE TO ENCAMP, AND PICKET, the drivers dismount and unhook; the markers take up an alignment twelve yards in rear of the battery, and facing it, for the line of pickets; the marker of the centre division in the centre; the others extend from him the number of yards there are horses in each half battery. One staff serjeant ten yards in rear of the centre marker indicates the alignment for the men's tents. The second staff serjeant twenty yards in rear of the other, to mark the spot for the captain's marquee. Nos. 1 and 6 unlash tents; 4 and 5 of each sub-division are told off for the marquee; 2, 3, 7, and 8 take a picket each, 9 a maul, and the wheel drivers a picket line.

Encamp, and picket.

At the word ENCAMP, AND PICKET, the numbers with the pickets form on the centre marker, facing to the front, the numbers with the mauls in front of and facing them.

The staff officer gives OUTWARDS FACE—QUICK MARCH, when the men with pickets extend outwards, dividing themselves at equal distance along the alignment taken up by the markers.

The staff officer dresses them, and gives the word STEADY, when the numbers with the mauls commence to drive the pickets.

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* From "Field Battery Exercise," &c.

The markers dismount, and assist the wheel drivers in making fast the line from centre to flanks, taking two half hitches round each picket, above and below the hook.

The horses are then brought up, the marker's horse of the centre division in the centre, the spare horses on each side of him, the wheelers, centre horses, and the leaders of the centre waggon next, and the rest in succession; the officers' and N.C. officers' horses on the flanks of their respective divisions.

Fastening the horses.

The horses are fastened by the centre of the collar chains to the line, taking two half hitches round it; the T end being also passed through the diamond link.

Nos. 1 take up an alignment ten yards in rear of the pickets, for the men's tents. They are dressed by the staff serjeant.

The centre of the tent is indicated by a peg; they then drive four guy pegs to the front, rear, right, and left, at three yards distance from the centre one. Nos. 6 spread out the tents, and fix the second cord from each side of the door to the front peg, the fifth cord on each side to the side pegs, and the rear cord to the rear peg. They then put the tent pole into the canvas, lying on the ground.

Raising the tents.

As soon as all is ready, the commanding officer gives the word RAISE THE TENTS, which is done by Nos. 6. Nos. 1, and 6 then drive in their pegs, and fasten the remaining cords.

Preparing the marquee.

The second staff serjeant dismounts, and the position of the marquee is indicated by two pegs, driven at a distance equal to the length of the ridge pole, on the spot where his horse stood. Nos. 4 and 5 of each sub-division (being detailed for the marquee), fall in, and are told off by the second staff serjeant, from 1 to 12; as eight men only are required, the remainder are spare. 1, 2, 3, and 4 spread out the roof, the outside on the ground, the door to the rear; 5 and 7 double the lining, lay it on the roof, and put in the ridge pole; 6 and 8 put the standards together, and pass them through the lining; 5 and 7 fix the girthing and ridge pole on the spikes. The inside being thus arranged, half of the roof is turned over in order to prepare the outside. Nos. 1, 2, 3 and 4 fix the vases on the spikes, and take two half hitches round them with the centre of each guy.

The marquee is raised by 5, 6, 7 and 8, at the same time as the tents. Nos. 1, 2, 3 and 4 take a guy peg and a mallet each, stretch the guys, and fasten them to the pegs in such a manner that they cross each other at each side, at the point of the dirk, which is painted on the roof; they then drive in the roof pegs, working round to their left, with their backs to the marquee; the pegs on the sides to be driven in a line parallel to the marquee; but at the ends in a half circle; 5 and 6 then hook on the wall from rear to front, overlapping two hooks at the rear, and peg it down; 7 and 8 hook on the lining, and peg it down; 5, 6, 7 and 8 also arrange the door. If there is a second marquee, it is fixed in the same manner.

As soon as the pickets are driven, Nos. 2 and 3 of each sub-division pitch the subalterns' tents, directed by the staff serjeant, ten yards in rear of the men's tents, in the centre of their division, the doors to the front; Nos. 7 pitch the guard tent, twenty yards in front of the centre of the battery, the door to the front.

Sec. 30. *Second method.*

The battery being formed in line, at half intervals, the horses are picketed, and the men's tents pitched on each flank; the officers' tents in rear.

At the word PREPARE TO ENCAMP, AND PICKET, the markers of the flank divisions mark twelve yards from the flanks of the battery for the line of pickets, facing to the rear.

At the word ENCAMP, AND PICKET, the picket numbers of each half battery form on the markers facing the battery; the numbers of the centre sub-divisions next the markers; they are faced to the rear, extended at equal distances, and dressed by the officers of the flank divisions; the distance they extend must be regulated by the number of horses in each half battery, allowing one yard for each horse.

The men's tents are ten yards outside of the line of pickets, facing the horses of their own sub-divisions, dressed by the staff serjeants.

The subalterns' tents ten yards in rear of the last line of carriages, and the commanding officer's marquee ten yards in rear of them.

The guard tent as in the first method.

All the duties of picketing the horses, pitching the tents and marquees, are performed by the same numbers as detailed in the first method.

Arrangement of the harness.

If the harness is to be taken off, it is placed in line, ten yards behind the horses. The traces, breeching, and collars are put inside the pad, which is laid inside the saddle; and the whole is kept compact by buckling the surcingle of the saddle tight round it; the bridles are laid over the cantles, which are towards the horses.

Sec. 31. *To strike the Encampment.*

The horses being harnessed and hooked in, at the word STRIKE TENTS, AND PICKETS, the pickets are struck at once; the tents and marquees prepared for striking by pulling up all the pegs except the guy ones. At the word DOWN, the whole are lowered together, and packed up as quick as possible.

With a brigade of batteries, the commanding officer's marquee would be pitched fifteen yards in centre, and in rear of the whole, door to the rear, by the spare marquee men of each battery. The pickets and tents of the whole brigade would be pitched in line, dressed by the adjutant, and serjeant-major.

WEIGHT, DIMENSIONS, ETC., OF TENTS.

BELL TENT, CIRCULAR.

	ft.	in.			in.
Standards, length	10	3	in two pieces	diameter	2

Pins, 40. Mallets, 2.
Weight of Tent complete, 60 lb.

LABORATORY TENT, CIRCULAR.

	ft.	in.				in.
Standards, length	16	3	in two pieces.	diameter.	Top	3
					Bottom	5

Mallets, 2. Pins—Large, 4; Small, 100.
Weight of Tent complete, 2 cwt. 10 lb.

HORSES.

The average weight of Artillery horses is 10 cwt. 2 qrs.

An allowance of 27 square feet is generally made for each horse standing at picket, or three feet in breadth, and nine feet in depth.* A horse should seldom be made to draw more than three cwt. besides the weight of the carriage. With great burthens, less weight must be allowed for each horse to draw than with medium burthens; as with a team of horses, the leaders cannot draw so much as the horses nearer the carriage, and the disadvantage must increase in proportion to the lengthening of the team.

A Team of	4	horses	may each draw	6 cwt.	Total, 24 cwt.
	6	do.	do.	5 do.	30 do.
	8	do.	do.	4 do.	36 do.
	12	do.	do.	4 do.	48 do.

These weights include the carriages. It is usual, however, in heavy carriages, to reckon all their weight exceeding twelve cwt. as part of the load.

The most useful mode of applying a horse's power is in draught, and the worst is in carrying a load. This is owing to the structure of the animal. It has been found that three men, carrying each 100 lb., will ascend a hill with greater rapidity than one horse carrying 300 lb. When a horse has a large draught in a waggon, however, it is found useful to load his back to a certain extent; this prevents him from inclining so much forward as he would otherwise do, and consequently frees him from the fatigue of great muscular action. The best disposition of the traces in draught is when they are perpendicular to the collar; when the horse stands at ease, the traces are then inclined to the horizon, at an angle of about 15° ; but when he leans forward to draw, the traces should then become nearly parallel to the road. The most proper inclination, however, is determined from the relation which subsists between the friction, and the pressure, in every particular case.

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* In the transport of horses to Turkey (July, 1854,) in the Himalaya, and Simla steamers, the distance between the upright posts was 2 feet 1 inch in the clear per horse, and the length 9 feet.

When a horse is employed in moving a machine, by travelling in a circular path, the diameter of the path ought not to be less than twenty-five or thirty feet, and in most cases forty feet should be preferred: at all events, it must not be less than eighteen feet.

MANAGEMENT OF DRAUGHT HORSES.

Whatever the difficulties of a road or ground may be, ten horses are as many as can be harnessed with effect to one carriage. It is difficult for a greater number to act at the same instant, even if the pull be straight.

Before a carriage moves, the traces should be equally stretched out, that at the word "MARCH" every horse may act steadily at the same instant on the carriage, and not by jerks.

The distance of one horse's length between the carriages is always to be maintained on the best road, to prevent fatigue and unnecessary stoppage to the horses. In bad or difficult roads it may be necessary to increase the distance to double, or perhaps more, according to the nature of the ground.

After going up a short steep hill, the horses should be halted, but when that cannot be done, they ought to move slowly to recover their wind. Should the ascent be long, and steep, the road in a bad state, or when from any other cause the exertion is likely to be very great for the horses, a part of the carriages should halt, the leaders of them be hooked on to those in front, and when they arrive at the top, as many leaders sent back as may be necessary.

In going up a hill, a carriage may be halted to rest the horses, by bringing them across it, and locking the limber.

Whenever the ruts are very deep, the carriages must quarter the road, and if the road is narrow, and sunk between banks, the horses should be left to themselves, and not be hurried.

In passing over deep furrows, or small ditches or drains, the carriages should cross them obliquely: when they are crossed perpendicularly, the horses not only encounter greater difficulty, but they, as well as the harness, suffer much from the jerks. The former line of march should be resumed as soon as they are passed.

Maximum quantity of Labour.

The following Table shows the *Maximum quantity of labour*, which a horse of average strength is capable of performing at different velocities, on canals, railways, and turnpike roads; but in comparing this table with practice at the higher velocities, it is reckoned necessary to add one-third more than the useful effect for the total mass moved.

Velocities per hour.	Day's work.	Force of traction.	Useful effect per Day for a distance of one Mile on a Canal.	Level railway.	Level road.
Miles.	Hours.	lb.	Tons.	Tons.	Tons.
2½	11·5	83⅓	520	115	14
3	8·		243	92	12
3½	5·9		153	82	10
4	4·5		102	72	9
5	2·9		52	57	7·2
6	2·		30	48	6
7	1·5		19	41	5·1
8	1·8		12·8	36	4·5
9	·9		9	32	4
10	·75		6·6	28·8	3·6

Result of experiments with a light four-wheeled cart, weighing with its load 1000 lb., drawn upon different sorts of roads (12½ lb. having been deducted from the force of traction for the friction at the axles, which were of wood).

Turnpike-road, hard, dry	18	Force of traction required to move the carriage, independent of the friction at the axles.
Do. dirty	26½	
Do. new gravelled	130½	
Loose sandy road	191½	

Note.—An ox can draw about 4 cwt., and a pair of oxen 9 cwt., on a level road.

HORSE-SHOES.

There are three sizes of horse-shoes in the service, and also a smaller size made for mules.

	Size.		lb.	oz.
Weight of set.	1st	(not including the weight of nails)	7	0¼
	2nd	do. do.	6	4¼
	3rd	do. do.	4	8¼
	Mules	do. do.	2	14

NAILS.

LENGTH, WEIGHT, NUMBER, ETC.

					Weight of set. 32 Nails.
1st size.	No. of nails*	8	9	10	5½ oz.
Largest.	No. of each required	16	8	8	
2nd size.	No. of nails*	7	8	9	4½ oz.
	No. of each required	8	12	12	
3rd size.	No. of nails*	5	6	7	3½ oz.
	No. of each required	8	8	16	

Note.—These several nails are known by farriers according to their No.—viz., when they say shoes require nails, Nos. 8, 9, 10, this implies nails of 8, 9, and 10 pounds per thousand nails.

No. of Nails.	Length of Nails.	Weight of 1000 Nails.
188	2¾ inches.	10 lb.
187	2½ —	9 —
186	2⅜ —	8 —
185	2¼ —	7 —
184	2⅛ —	6 —
183	2 —	5 —

FORAGE.

Method observed in carrying one day's forage.

Non-commissioned Officers, and Trumpeters.—One feed of oats in the nose-bag, and buckled to the near-ring of the saddle. Three feeds in the corn-bag, and carried across the saddle. Twelve pounds of hay twisted, and rolled up into two bundles, each nine inches long, carried at the ends of the kitt, and made fast with the forage cord, one end to pass in front, and the other in the rear of the kitt, making it fast by two hitches.

Drivers.—One feed of oats for each horse, carried in the nose-bags, and made fast to the rear staples of the off-horses' saddles. Three feeds for each horse (six feeds) in the corn-bag, carried across the saddle of the near horse. The hay is twisted and rolled up into two bundles of twelve pounds, each eighteen inches long; carried on the off-horse at the ends of the kitt; the end of one forage cord passing in front of the kitt, the end of the other forage cord passing in rear of the kitt, both ends being made fast by two half hitches.

If a waggon accompanies the battery, the officers' horses' forage will be carried in it; if not, the oats are to be divided between the subdivisions, and the hay carried on the foot-board in front of the body of the waggon.

In heavy marching order, when forage is not ordered to be carried.

Non-commissioned Officers, and Trumpeters.—The nose-bags are rolled up and buckled to the near-ring of the saddle. Forage cord, currycomb and brush, mane-comb, picker, and sponge, are made fast, to the off-ring.

DAILY RATION FOR ONE HORSE.

	Oats.	Hay or Grass.		Straw.
	lb.	lb.	lb.	lb.
In Quarters	8	18	..	6
In Barracks	10	12 or	36	8

A load of Hay, or Straw	36 trusses.
A truss of Hay	56 lb.
Ditto Straw	36 lb.

PART VII.

VETERINARY DIRECTIONS.*

The ordinary dose of every Mass is One ounce (Avoirdupois).

No. I.—Cathartic Mass.

Aloes, Barbadoes	8 parts.
Olive Oil	1 „
Treacle	3 „

Dose, from 6 to 7½ drams of the mass, which contains 4 and 5 drams of aloes respectively.

Any horse to whom a dose of physic is given, should be fed on bran mashes, in lieu of corn, until its operation has ceased. If there be no cause for its immediate administration, let ample bran mashes be given, by way of preparation, in lieu both of hay, and corn, during one day, and the ball administered the following morning, after the horse is sufficiently watered, and a couple of hours at least before his bran mash be given him. Exercise, also, during the day is advisable. The following day, early in the morning, after the horse has had water, with the chill taken off, offered him, till he refuses to drink more, let him be walked out briskly for one hour, unless he purge, in which case let him be returned to the stable, littered down, frequently watered, and plentifully supplied with bran mashes. But should the physic not operate at the expiration of his exercise, nor after he has remained the four succeeding hours in the stable, let him be exercised for another hour; and he may be gently trotted at this time should he still show no signs of purging: let it be here understood, however, that in no case is a horse in physic to be galloped. To insure purgation, water is no less requisite than exercise.

Should the animal continue to purge on the third day, let him be kept short of water, and without exercise; if the purging still continue, give wheaten flour gruel, and hay; no exercise. As soon as his dung shall have put on its natural appearance, and consistence, the usual ration of provender may be restored, and he may return to duty.

When a sick, or lame horse requires physic, to which exercise would be injurious, or has not been properly prepared with bran mashes, the dose may be increased by one dram; and to him the ball may be given at any time, in order that its operation may be as speedy as possible. A dose of physic should never be repeated until the expiration of seven clear days from the setting of the previous dose.

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* Whenever a Veterinary Surgeon is present, these Directions are to be considered in abeyance.

Horses suffering from cough, discharge from the nose, or inflammation of the lungs, are not to have purgative medicine administered, but the febrifuge, or sedative mass should be given.

No. II.—Febrifuge Mass.

Nitrate of Potass . . .	3 drams.
Tartar Emetic . . .	2 scruples.
Camphor	1 dram.

Common mass, a sufficient quantity to form a ball, to weigh one ounce for one dose, which may be given once, or twice a day, for a day or two.

In coughs, or discharge from the nose in which fever is present, this mass is especially useful. Let the animal be warmly clothed, littered down, be kept quiet in a well-ventilated box, and fed on equal parts in bulk, of bran and oats, mixed with cold water: head steamed with hot water, and a little hay, in a bucket.

No. III.—Sedative Mass.

Extract of Belladonna . .	2 drams.
Nitrate of Potass . . .	3 „
Tartar Emetic	1 „
Camphor	1 „

Common mass, a sufficient quantity to form a ball to weigh one ounce, which may be repeated once, or twice a day, for two, or three days.

In case of inflammation of the lungs, these balls are especially beneficial. After having drawn from five to eight quarts of blood, according to the violence of the symptoms, and the apparent strength of the animal, give a sedative ball once, or twice a day at regular intervals. Let the sides of the chest be well rubbed with some of the blistering liquid, clothe warmly, rub the legs, and bandage with flannel; keep the stable well ventilated.

Should the symptoms be the same the next day, and the blister has not risen, it may be repeated with the additional application of it to the chest; also, if the cough be frequent, to the throat;—the sedative balls being continued, and clysters given.

No. IV.—Diuretic Mass.

Nitrate of Potass Resin Hard Soap	Equal parts. Dose, one ounce.

Diuretic balls may be given, one every third night, in all cases in which they may be required: seldom is it necessary to administer one every other night, and still more rarely every night.

Should the flow of urine prove abundant, the horse frequently making efforts to stale, and groaning in so doing; or, if he cannot stale, but appear to experience pain about the loins and hips, and be stiff in moving those parts, diuretic balls must on no account be given. Diuretics are beneficial in recent swelling of the legs: linen bandages, and walking exercise may be had recourse to at the same time. Diuretics are also useful in watery farcy, dropsy, and puffy or watery swellings of all kinds.

No. V.—ALTERATIVE MASS.

Aloes, Barbadoes . . .	2 drams.
Ginger	1 dram.

Common mass sufficient to form a ball to weigh one ounce.

To ill-conditioned horses that do not thrive, notwithstanding they eat, and appear otherwise in health; to horses that rub themselves, or that have small lumps or bare places upon the skin (not mange), one of these balls may be given every fourth day, but not more than three balls altogether.

Bruised corn, hay cut into chaff, bran, and frequent and full supplies of water, contribute to restore such horses to condition. Walking exercise once, or twice a day, according to the strength of the horse, is also recommended.

No. VI.—ANTI-SPASMODIC DRAUGHT.

Spirits of Nitre	2 ounces.
Tincture of Opium . . .	1 ounce.
Water	4 ounces.

In the generality of cases of gripes this will prove sufficient; but if the horse be not better in one hour, the draught may be repeated with, or without the addition of half a pint of linseed oil. Clysters also will be found of great benefit. When the horse continues alternately to lie down, and rise in the stall, and to roll upon his back, relief will frequently be given by walking exercise for ten minutes.

Those cases in which the symptoms do not intermit, and in which the pulse and breathing are much quickened, are not gripes, but inflammation of the bowels. Take away from six to eight quarts of blood without loss of time, and give a draught composed of aloes, four or five drams; powdered opium, two drams, dissolved in one pint of warm water; give frequent clysters of warm soap and water; rub well upon the belly a strong mustard poultice, composed of mustard, warm water, and liquid ammonia, or oil of turpentine, or a liniment composed of equal parts of oil of turpentine, and liquid blister. Hand-rub and bandage legs—clothe warmly.

If the symptoms do not abate, give powdered opium, one dram every two hours in warm water; continue clysters, and repeatedly offer the horse warm water to drink. The mustard poultice should also be repeated.

No. VII.—Vermifuge, and Tonic Powder.

Sulphate of iron, 6 drams, divided into twelve doses, is a good remedy for worms—one dose to be given once a day in some bran mash, until the number is consumed. The horse may continue to work.

It also is useful as a tonic, given in the same manner, the dose being doubled to horses that are low in condition, or recovering from the effects of disease, the medicine being aided by generous feeding.

No. VIII.—Anti-purgation Mass.

Extract of Catechu	1 dram.
Cinnamon Bark	1 ,,
Powdered Opium	½ ,,

Common mass—sufficient to form a ball to weigh one ounce.

The above mass is very useful in all cases of excessive purging, either from the effects of disease, or from an overdose of purgative medicine. The ball may be repeated two or three times a day, thick wheaten gruel being given at the same time.

No. IX.—Discutient Powder.

Sulphate of Zinc . . . . 4 drams.

This, mixed with one quart of cold water, will be found a very useful application to sore backs, withers, shoulders, and to recent swellings from blows or injuries of any kind. Bandages wetted with this lotion may be used for sprains of the joints, and back sinews.

No. X.—Astringent Ointment.

Acetate of Lead	1 part.
Lard	3 parts.

This will be found useful in cases of grease, where the discharge is but little, and not very offensive. Apply a little to the heel, then a piece of fine tow, and over that a tailed bandage. Give walking exercise, and a diuretic ball occasionally. But should there be much swelling, and the discharge copious and fetid, apply a warm bran poultice, over which sprinkle some powdered charcoal, feed on bran, and give a mild dose of physic. When this treatment has had the desired effect, the ointment may be used with advantage.

No. XI.—Ophthalmic Powder.

Sugar of Lead . . . . 2 drams.

So long as the eyes appear red, and inflamed, cold water alone should be made use of, and with it they should be kept continually wet. When the inflammation is abated, sponge the eyes and eyelids several times a day with a lotion, made by dissolving the sugar of lead in a quart of cold soft water.

In all cases where there is much inflammation, a dose of physic should be given.

No. XII.—Blistering Liquid.

Powdered Cantharides . .	4 ounces.
Olive Oil	1½ pint.

This is very useful as a counter-irritant in all cases of internal inflammation (see Nos. 3, and 6). It is also useful in swellings, sprained joints or sinews, curbs, spavins, &c., after the inflammation attending these diseases has subsided.

No. XIII.—Digestive Ointment.

Common Turpentine Hog's Lard.	Equal parts, melted together.

This ointment is the best application that can be made use of in cases of treads, or wounds on the coronet, between hair, and hoof; a small quantity is to be spread upon a plugget of tow, and bound on with a bandage. It is likewise a good dressing for broken knees (when the joint is not open) or cuts, to promote healthy action.

No. XIV.—Turpentine Liniment.

Oil of Turpentine Olive Oil	Equal parts.

In cases of sore throat, cough, and in all cases where a mild counter-irritant is required, this liniment will be found useful.

No. XV.—Hoof Ointment.

Tar Lard	Equal parts, melted together.

This ointment is intended for brittle feet, or such as have sand-cracks; also, with tow, to form the stopping to be placed under leather soles.

PART VIII.

CONGREVE ROCKETS.

ROCKETS may be of great use when a disembarkation of troops takes place in presence of an enemy, since Rocket men can land with the first party of Infantry, and commence firing before any guns can be brought into position. Rockets will not only be useful against masses of Cavalry, and squares of Infantry, but, when guns cannot be brought up, may be of material benefit in dislodging an enemy from villages or houses, which could not be approached by Infantry alone without a considerable loss of men, and chance of failure. The larger rockets are of great service in bombardments, and sieges.

Congreve Rockets are of four different natures--viz., 24 pounders, 12 pounders, 6 pounders, and 3 pounders. The cases are of wrought iron, and the rockets are driven upon the same principle as Signal rockets. Congreve rockets may be used either as shot, or shell-rockets, and the shell may be made to burst either at long or short ranges. Each rocket is fitted with a fuze screwed into the base of the shell; this fuze is as long as the size of the shell will admit of, so as to leave sufficient space between the end of it and the inner surface of the shell, for putting in the bursting-powder, and the end of the fuze is capped to serve as a guide in the insertion of the boring-bit. There is a hole in the apex of the shell, secured by a screw metal plug, for putting in the bursting-powder, and for boring, according to the different ranges at which it may be required to burst the shell.

ON FIRING ROCKETS.

If the Rocket is to be used as a Shot-rocket, the only thing to be attended to, is to take care that there is no powder in the shells, and that the plug is secured in the plug-hole. If the rocket is to be used as a shell-rocket at the longest range, the plug is to be taken out, and the shell filled, the fuze left at its full length, and the plug replaced. If at the shortest range, the fuze is to be entirely bored through, and the rocket composition bored to within an inch and a half of the top of the cone in the 24 pounder rocket, and to within one inch in the 12, 6, and 3 pounder rockets. The distances from the surface of the shell to the top of the cone, and from the surface of the shell to the end of the fuze, and also, the length of the fuze being fixed and known, the place on the boring-bit at which to screw the stopper, whether for various lengths of fuzes, or lengths of rocket composition to be left over the cone, is easily determined; these distances are marked on the brass scales for each nature of rocket, and the length of rocket composition available for boring into, and the lengths of fuze, are also set off and subdivided into tenths of an inch.

ELEVATIONS, RANGES, AND LENGTHS OF FUZE.

The 24 pounder, and 12 pounder rockets are very destructive against troops from 800 to 1000 yards; against buildings, &c., from 500 to 600 yards: with 6 pounders about 300 yards, and never at a greater range than 600 or 700 yards.

The range and elevation of a 12 pounder rocket is 10 degrees of elevation for 600 yards, and 1 degree more is given for each additional 100 yards, as far as 1250 yards, the elevation for which will be 16 degrees.

The range and elevation of a 6 pounder rocket is 7¾ degrees for 400 yards, and as far as 700 yards 1 degree for each 100 yards; and from 700 to 1250 yards, half a degree increases the range about 100 yards.

24 *pounders.*—If the whole length of fuze is left in the shell, the rocket may be expected to burst at from 3300 to 3700 yards; elevation, 47 degrees.

If the whole of the fuze composition is bored out, and the rocket composition left entire, the shell may be expected to burst at about 2000 yards; elevation, 27 degrees.

If the rocket composition be bored to within 1·5 inch of the top of the cone, the shell may be expected to burst at about 700 yards; elevation, 17 degrees.

12 *pounders.*—If the whole length of fuze be left in the shell, the rocket may be expected to burst at about 3000 yards; elevation, 40 degrees.

If the whole of the fuze composition is bored out, and the rocket composition left entire, the shell may be expected to burst at about 1300 yards; elevation, 15 degrees. If the rocket composition be bored to within one inch of the top of the cone, the shell may be expected to burst at about 500 yards; elevation, 9 degrees.

6 *pounders.*—If the whole length of the fuze be left in the shell, the rocket may be expected to burst at about 2300 yards; elevation, 37 degrees. If the whole of the fuze composition be bored out, and the rocket composition be left entire, the shell may be expected to burst at about 950 yards; elevation, 13¾ degrees. If the rocket composition be bored to within one inch of the top of the cone, the shell may be expected to burst at about 500 yards; elevation, 9½ degrees.

3 *pounders.*—If the whole length of the fuze be left in the shell, the rocket may be expected to burst at about 1850 yards; elevation, 25 degrees. If the whole of the fuze composition be bored out, and the rocket composition be left entire, the shell may be expected to burst at about 750 yards; elevation, 10 degrees. If the rocket composition be bored to within one inch of the top of the cone, the shell may be expected to burst at about 500 yards; elevation, 8 degrees.

Ranges, and Elevation of Congreve rockets.

Ranges.	Elevation.			
	12 Pounder.		6 Pounder.	
Yards.	Degrees,	Minutes.	Degrees,	Minutes.
400			7	45
500			8	45
600	1		9	45
700	11	30	10	30
800	12	45	11	15
900	13	30	11	45
1000	14	..	12	30
1100	14	45	13	15
1209	15		14	..
1250	16		14	30

EXERCISE OF ROCKETS.*

The 24 pounder is used for siege purposes. The 12, and 6 pounders are for service in the field.

EXERCISE OF 12, AND 6 POUNDER, OR FIELD ROCKETS.

Telling off the Detachment.

The detachment falls in, in rear of and facing the carriage, and is told off as for gun exercise.

† "FORM THE ORDER OF MARCH, LEFT FACE—QUICK MARCH."

Disposition, and Duties of a Detachment of Seven Men, with a 12, and 6 pounder Rocket.

No. 1 stands one yard in rear of the tube, points, and commands.

3 stands on the left of the tube, in line with its centre, elevates, and traverses.	2 stands on the right of the tube, in line with its centre, elevates, and traverses.
5 stands on the left of the tube, in line with the rear of it, primes, and fires.	4 stands on the right of the tube, in line with the rear of it, brings up rockets, arranges the priming, and loads.
7 stands in rear of the carriage and prepares rockets. When firing shell rockets, he bores out the composition, assisted by No. 6.	6 stands in rear of the carriage, assists No. 7 in preparing rockets. When firing shell rockets he puts in the bursting powder, &c.

The following is the proportion of Stores furnished with Field Carriages.

Two hundred and sixteen rockets with sticks. } with
Two hundred and sixteen bursters. } 6 pounder.

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* From "SERVICE AND MANAGEMENT OF ORDNANCE."

† *Words of command.*

One hundred rockets with sticks. *One hundred bursters.*	with 12 pounder.
One rocket frame, comprising two cheeks, a pry-pole, elevating bar, and tangent scale. Two funnels. One boring stock. Two boring bits. One brass scale fitted to bits. *Two turnscrew bits. One grease box. One tube pocket with tubes. One lanyard with hook* for friction tubes.	with both natures.

To every other equipment not exceeding 144 *Rockets.*

One stick for each rocket. One burster ditto. Two funnels. One boring stock. Two boring bits. One brass scale fitted to bits. *Two turnscrew bits. One grease box. One tube pocket with tubes. One lanyard with hook* for friction tubes.

One angle. One plummet with line. One elevating chain. Two guy ropes. Two additional pieces for the cheeks.	with 24 pounder.

On field service the bursters are carried in the limber boxes, in canvas cartouches, similar to those in which the field ammunition is carried. The 12 pounder rocket carriage takes 50 bursters in each limber box, and the small stores in a box on the body of the carriage corresponding to the slow match box. The 6 pounder carriage takes 108 bursters in each limber box, and the small stores in a box which is between the limber boxes. In mountain equipments the bursters, and small stores are carried in a box fitted to the pack saddle.

* ACTION FRONT, REAR, RIGHT, OR LEFT. DRIVE ON. LOAD. ELEVATE. LOWER. HALT. MUZZLE RIGHT, (OR LEFT). HALT. Priming, and Firing, as at Field guns.

EXERCISE OF 24 POUNDER, OR SIEGE ROCKET.

Disposition, and duties with seven men.

When the detachment is in action, the disposition and duties of the numbers are the same as at the lighter natures.

* PUT THE FRAME TOGETHER AT LOW ORDER. RAISE THE FRAME. REEVE THE GUYS. SLING THE ROCKET TUBE, AND FIX THE ANGLE. ADJUST THE FRAME. LOAD. TRAVERSE, when necessary, MUZZLE RIGHT, MUZZLE LEFT. If greater alteration be required, than can be given by means of the guys, the cheeks of the rocket frame are moved in the named direction, CHEEKS TO THE RIGHT, (OR LEFT). ELEVATE, when necessary. Priming, and Firing, as directed for Field guns. When the frame is fixed *at Low order*, the pry-pole forms an angle of 30 degrees with the horizon. If greater elevation than this be required, the frame must be raised to *High order*—45 degrees elevation; or higher still—50 degrees elevation.

PREPARE TO RAISE THE FRAME TO HIGH ORDER. JOIN THE CHEEKS. RAISE THE FRAME. ADJUST THE FRAME. LOAD, ETC. PREPARE TO STRIKE THE FRAME. STRIKE THE FRAME.

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* *Words of command*—SMALL CAPITALS.

PART IX.

SERVICE, AND MANAGEMENT OF ORDNANCE.

PART I.—ELEMENTARY INSTRUCTION IN MOVING HEAVY ORDNANCE.

ARTICLE 1.*—LEVER, AND HANDSPIKE.

THE lever is of essential use in the service of artillery. When it is six feet long, and three and a half inches square at the large end, called the 'point,' it is termed a handspike, a larger handspike 7 feet long is used with 68 pounder, 10 and 8 inch guns.

The greater the length of the lever, the greater is its power.

A man using a lever always applies his strength as near the end of it as he can.

Slewing.

To slew a gun, or mortar, strictly speaking, is to turn it on its axis without moving it from the spot on which it rests. This is called slewing the trunnions.

If the piece to be slewed rests on skids, a handspike is placed close to it on each skid, bevel-up, and on that side of it towards which it is to be turned. This is called scotching, or chocking, and the handspikes are called "chocking handspikes."

The term slewing is also applied to turning a gun, or mortar horizontally, upon a pivot. This is called slewing "end for end."

Pinching.

Pinching is the operation of moving a gun, or mortar by small heaves of the handspike, without allowing it to turn on its axis. It is moved little by little, and never raised in its progress, but rubs against the skid on which it rests.

Cross Lifting.

To cross lift a gun, or carriage is to move it in a direction nearly perpendicularly to its axis.

Parbuckling.

To parbuckle a gun is to turn it, on its axis, so as to cause it to move in either direction *from* the spot on which it rests. For this purpose the gun must be placed on skids, and, if it is to be moved up or down a slope, two 4½ inch ropes must be made fast to some suitable object on the upper part of the slope, the ends carried under the chase and breech of the gun respectively, round it, and up the slope. If the running ends of these ropes are hauled upon, the gun ascends; if eased off, it descends.

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* The size of "The Artillerist's Manual, &c.," being limited, only a portion of the PARTS, and ARTICLES of "SERVICE AND MANAGEMENT OF ORDNANCE," has been selected for the present publication.

If the ground is horizontal, handspikes only are necessary to move the gun.

Fulcrums, and Props.

Any piece of strong timber of suitable dimensions may serve for a fulcrum, or a prop. It is called a fulcrum when used to support a lever, and a prop when used as a temporary support for anything else.

Fulcrums.

The distance of the fulcrum from the weight which is to be raised should be such that, when the lever rests upon the top of it, the point may be put under the weight, and the lever form such an angle with the horizon that, when it is heaved down, and the small end nearly touches the ground, the weight may be raised to the required height.

Except with very heavy bodies, care must be taken, in placing a fulcrum, that it is inclined in a small degree towards the body, so that when the lever acts it may bring the fulcrum into a vertical position.

Props.

There cannot be a better prop than a quoin, when it is long enough, or a piece of wood of that shape, of proportionate size.

If the wheels of a carriage are to be taken off, and the carriage propped, the trail should be first secured from slipping.

The props are placed under each cheek, or under the shoulder of the axletree, with a slight inclination towards the carriage.

When one wheel only is to be taken off, and the other scotched, the props may be placed vertically; but practice alone will point out the proper position of props in all situations.

The point of the lever must not be withdrawn, until it is evident that the prop is well placed.

ARTICLE II.—LIFTING JACK.

The lifting jack forms part of the equipment of every battery and battering train. It may be applied to many of the purposes for which a long lever is used; but it is commonly employed to raise the wheels of carriages from the ground when they are to be greased, or exchanged, and to extricate them from ruts and holes.

The wheel opposite to that which is to be raised, must be scotched.

On soft ground, a piece of board must be placed under the foot of the jack, to prevent its sinking.

There are at present three kinds of lifting jacks in the service:—

(1) "The common lifting jack" is used for field carriages only. The arm, which may be adjusted, within certain limits, to any

required height, is a lever of the first kind, and is applied accordingly. The body of the jack is the support on which it works.

(2) "The tooth and pinion jack" is of greater power than the common jack, and is used for heavy carriages. It is applied vertically under the carriage, which is raised by turning the winch of the jack.

(3) "The screw jack" is an elevating screw of large dimensions, and is of greater power than either of the other two. Like the tooth and pinion jack, it is applied vertically under the body, which is raised, like the breech of a gun, by turning up the screw. The foot of it is furnished with three spikes, to prevent its slipping when the screw is turned.

These two last-mentioned jacks will be superseded by that proposed by Major Clerk. The new pattern jack is the elevating screw of the service, in a cast-iron conical box with metal top and triangular base. The length of the screw is 13 inches, diameter 2¼ inches, pitch ½ inch; length of lever 3 feet; weight 64 lbs. This screw is fitted, near the top, with a horizontal toothed wheel, for the reception of corresponding teeth in the lever. The fixed end of the lever is connected with the screw by a collar and slot. When the lever is raised it has free motion round the screw; when it is lowered the teeth are engaged, and a purchase is taken. The foot of the screw is fitted with a claw. The lever is in two parts for convenience of transport. To run the screw quickly down, the lever should be unshipped. Oil is used to lubricate the jack.

ARTICLE III.—ROLLERS.

Rollers are solid cylinders of wood, used in mounting guns upon their carriages, in shifting them from carriage to carriage, and in moving them on the ground. Their dimensions vary, according to the nature of the service for which they are intended.

They can be used with advantage only on a perfectly plane and hard surface.

When a gun is moved on rollers, they must be perfectly horizontal, or it will roll off them; and even when the rollers are horizontal, steadying handspikes should be applied, to guard still further against such an accident.

The rollers must be placed at right angles to the direction in which they are intended to move, projecting equally on each side of the axis of the gun, or other body, which they support.

A gun laid upon rollers may be moved, either by hauling upon it with ropes, or by means of levers. In the last case, two holes crossing each other at right angles, are pierced near each end of the several rollers, and in them are inserted the points of iron levers, by means of which the rollers are turned in the required direction.

ARTICLE IV.—CRAB CAPSTAN, AND TEMPORARY WINDLASS.

A crab capstan consists of a barrel (in shape a frustrum of a cone), and of a framework of wood and iron by which the barrel is supported in a vertical position with its largest diameter next the ground. It is furnished with two levers, called capstan bars, which are passed through mortices in the upper part of the barrel, and by means of which the barrel may be turned about on its axis. By means of the crab capstan, a few men, acting at the bars, can move weights which would be far beyond their strength, if applied in the ordinary manner; and it may, therefore, be used with advantage, in many situations, in which it may be either difficult to command labour, or desirable to economise it.

One end of a rope is made fast to the weight which is to be moved, and is called the "standing end." The other, called the "running end," is passed two or three times round the lower part of the barrel, the loose or running end being kept above the turns, and stretched taut by the man who passed it round. As the barrel is turned, the standing end of the rope winds round it, forces the turns up the barrel, and clears itself. As fast as the running end comes off the barrel, it is coiled by a man appointed to that duty.

The capstan, when used, is secured by ropes to pickets, or other holdfasts on the opposite side of it to that on which the strain acts upon it.

PART II.—SERVING, AND WORKING HEAVY ORDNANCE.

ARTICLE I.

A gun detachment consists of one Non-commissioned officer, and nine Gunners.

"Telling off." The men fall in, on their private parade, two deep, the non-commissioned officer gives the word "Tell off." The right-hand man of the rear rank numbers off "2," his front rank man "3," the second man from the right of the rear rank "4," and so on.

The detachment being in line, the non-commissioned officer is on the right of the front rank.

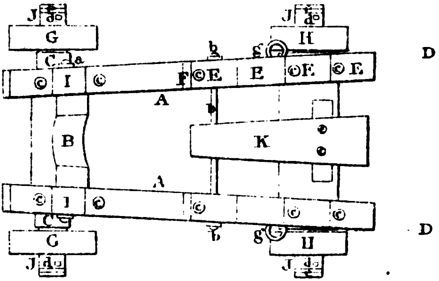
The detachment is marched into the battery, and is halted in line, facing the parapet, and to the left rear of the gun which is to be worked. The detachment is now in the position of "Detachment rear," or that which it occupies when it comes into the battery as a relief, and whilst the relieved party is marching off.

At the word "Take post under cover," No. 1 gives "To the right face," and, taking an oblique pace to his left rear, "double march." The detachment, stepping off, wheels to its left at the left corner of the platform, the front rank filing to the left of the gun, the rear rank to the right; Nos. 2 and 3 halting close to the parapet, and near the mouth of the embrasure, the other numbers forming upon their right and left in succession. No. 1 following in rear of the rear rank; they face to the right about together.

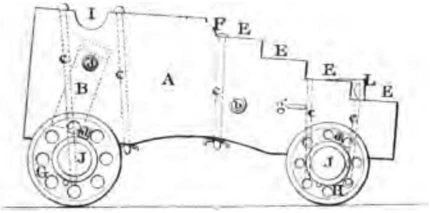
The detachment, now close to the parapet, is in the position it should occupy when not actively engaged in working the gun.

When there is no parapet the detachment files at once on to the gun, at the command, "Take post at the gun," Nos. 2 and 3, halting in line with the muzzle, Nos. 4 and 5 the trunnions, Nos. 6 and 7 the vent, No. 1 the trail, and the whole in echellon, and uncovered.

PLAN OF A GARRISON CARRIAGE.



A	*Sides or brackets*
B	*Transom*
C	*Fore axletree*
D	*Hind axletree*
E	*Steps*
F	*Quarter round or ovolo*
G	*Fore truck*
H	*Hind truck*
I	*Trunnion hole*
J	*Axletree arm*
K	*Stool bed*
L	*Quoin*
a	*Transom bolt*
b	*Bed bolt*
c	*Bracket bolts*
d	*Linch pins*
e	*Axletree hoops*
f	*Stool bed bolts*
g	*Eye or loop bolts*



ELEVATION OF A GARRISON CARRIAGE.

GENERAL DETAIL OF DUTIES FOR DETACHMENTS OF TEN MEN AT ALL HEAVY GUNS.

No. 1 points, and commands.

No. 2 searches, sponges, rams home, elevates.

No. 4 clears the vent, serves it, pricks cartridges, traverses.

No. 6 supplies side arms to No. 2, taps and cleans sponge if necessary, attends stool bed, elevating screw and quoin in laying, replaces No. 1's handspike, has charge of water buckets, assists to load the projectiles for 8 inch, 10 inch, and 68 pounder, and also hot shot.

No. 3 loads, assists to ram home, elevates, uncaps fuze when in bore.

No. 5 serves No. 3 with projectiles, and wads if necessary, and traverses.

No. 7 serves No. 3 with cartridge, primes, and fires. Has charge of lanthorn, for night firing.

The above numbers run the gun up.

No. 8 assists to prepare shells, and to supply gun with projectiles, and spare stores when necessary. Brings up cartridges from magazine.

No. 10 attends to the magazines, serves out cartridges to No. 7.

No. 9 fixes and bores fuzes, assists to prepare, and bring up projectiles.

Besides the men told off as above, some will be required to move powder barrels, rivet on bottoms, fill shells, heat shot, &c.

GENERAL LIST OF STORES REQUIRED FOR SERVICE OF GUNS ON STANDING CARRIAGES.

Side arms.	1 sponge. 1 rammer. 1 wadhook.	To be placed on the right of the gun, clear of the detachment when under cover. Heads of side arms uppermost, and just below the crest of parapet. When in casemates, or blindages, or when there is no parapet, the side arms must be laid on the ground, parallel to the gun, heads to the rear, and supported to keep them off the ground.
Handspikes, 5: points to the front.		Two on each side of the platform close to the edge of it, front handspikes, or those of No. 2, and No. 3, outside, and two feet in advance of those of No. 4, and No. 5. No. 1's handspike in rear of platform.

Priming irons for Garrison guns. Sets 1. In loop on right side of carriage.

Thumbstalls. 1. With No. 4.

Cartridge cases. 2.	One at the gun with a cartridge, the other at the magazine.
Tube pocket with straps. 1.	Containing tubes strapped round waist of No. 7.
Mallet. 1. Fuze wrench. 1. Fuze borers. 2. Trail box. 1. Keys for shells. 2. . . .	Either in shell room, or under cover of parapet.
„ for portable magazine . . 1.	
Lanyard, with hook. 1.	With No. 7.
Hammers, claw. 1. Ditto, wrench. 1. Tangent scales, wood 1. Stop quoin. 1.	With No. 1.
Shot. Solid, or hollow. Grape. Case . . .	Piled on left of gun, close to front of platform, the round shot enclosed in a large grummet, or garland.
Wads, junk, or grummet.	On left of shot; the former for hot, the latter for cold shot.
Shells, filled in boxes, Common. Shrapnel.	Either in shell room, or under cover of parapet, &c.
Cartridges filled.	In portable magazines.
Fuzes, shrapnel. „ common.	In boxes in shell room, &c., one per shell.
„ concussion.	One per common shell.
Tubes, friction.	Three for two projectiles. In tube pocket, and zinc cylinders in shell room, &c.
Portfires . . Slowmatch .	A small proportion at magazine.
Lanthorn. 1.	In charge of No. 7.
Water bucket. 1.	
Grease box. 1. Broom. 1. Shovel. 1. Spade. 1. Pick. 1. Sand Bags. 6. Spun yarn	In charge of No. 1.
Spikes, common. 1. „ spring. 1.	In charge of No. 1.
Spare screws for sights. 4.	
Wrench for ditto.	
Shot gauge.	

EXERCISE OF GUNS ON STANDING CARRIAGES.

Preparation for Action.

Should the gun not be provided, at the words, "Prepare for action," the Detachment acts as follows :—Running to the store,

The first first five numbers (1, 2, 3, 4, 5) bring up handspikes, and

No. 2, assisted by No. 4, also brings up side arms.
 „ 4 priming irons.
 „ 3, and No. 5 the case, grape, and wads (the round shot is supposed to be at the gun).
 „ 6 water bucket, and elevating screw, if the carriage has been fitted with one.

No. 7 the tube pocket, tubes, lanyard, and cartridge case.
„ 8, and No. 9 portable magazine, if required, and afterwards bring up, and prepare shells, in their boxes. When there is no shell room, the implements for boring, and fixing fuzes are kept in the trail box, and near the shells.
„ 10 goes to the expense magazine.

With trained men the detachment proceeds direct to the store, and brings up at once all that is required for the service of the gun.

ARTICLE II.—EXERCISE OF GUNS ON TRAVELLING CARRIAGES.

Heavy guns require the following number of men for their service in the field, viz. :—

Three Non-Commissioned Officers, and thirty men,

being necessary on the march for extricating the guns out of difficulties,—taking up positions,—laying temporary platforms,—placing planks under wheels and trail to facilitate working the gun ;—and also for affording three reliefs when engaged in siege operations.

To shift a Gun from the Travelling to the Firing Holes.

The wheels should, if possible, be on a level, and scotched.

Words of command. "Shift the gun. Prepare to raise the breech. Bear down. Lower. Prepare to raise the muzzle. Lift, and heave. Halt. Prepare to raise the breech. Lower."

The operation of shifting from firing to travelling is the converse of this.

Major Clerk's Platform.

This platform consists of—

Two inclined planes 17 feet long, 12 inches wide, slope 3°.

One front transom 7′ × 16″ × 4″ laid flush with surface of ground, to which the inclined planes are pivoted.

Two sleepers, one 7′ × 6″ × 3″, the other 8′ × 6″ × 3″, these are laid flush with the ground.

One trail plank, 10′ × 16″ × 4″. This plank is placed on the ground, so that the trail may rest on it.

To lay the Platform, and mount Gun.

First.—Lay the front transom and sleepers flush with the surface of the ground, and level the ground between them.

Secondly.—Run the gun into position, then, with a screw jack, raise one wheel, run the inclined plane under it, and pivot it to the transom. Then the same on the other side. The ribands should be inside, and the inclined planes parallel.

Thirdly.—Lay the trail plank under the trail.

To traverse.

Draw out the iron bolts at the ends of the platform, then one man at each with a handspike, and two at trail of carriage; the trail plank has to be shifted when much traversing is required.

The whole of the platform is cut out of a log of fir 17′ × 16″ × 16″, and packs up into its original shape for travelling. Those parts of the platform which require strengthening are shod with sheet iron. The front transom and trail plank are furnished with spikes to secure them to the ground, and when packed, these spikes go into corresponding holes in the inclined planes, to keep them together; if the ground is soft, a picket is required behind the trail plank. When used with a garrison carriage, the inclined planes are pivoted to holes.

Weight 11 cwt. Tonnage [measurement] 30 feet.

ARTICLE III.—EXERCISE OF GUNS ON DWARF, AND CASEMATE PLATFORMS.

The general duties of the detachment are the same as those before described.

Some additional stores are required, viz., one preventer rope; two truck levers; two shod handspikes; but two common handspikes only are necessary.

At the command "Prepare for action," the different numbers bring up the stores as before detailed, and in addition, No. 1 the preventer rope, who passes the eye over the rear transom of the platform, and under the rear transom of the carriage to No. 3, who bolts it to the fore axletree of the carriage; Nos. 2 and 3 a truck lever each; Nos. 4 and 5 a shod lever, both parallel to the platform on their respective sides, and a set of luff tackle each; no handspikes; they hook the fixed blocks to the eye-bolts in rear of the platform, coiling up the falls on the ground immediately underneath them.

ARTICLE V.—HOT SHOT.

With some few exceptions the duties are the same as those before described.

No. 3 puts a dry wad over the cartridge, and then a damp one.

No. 5 as usual supplies 3 with wads, first a dry, then a damp one.

Nos. 8 and 9 bring up hot shot on a bearer, in the same manner as they brought up shells.

The sponge must be frequently damped.

The same stores are required as for the service of heavy guns with cold shot. Junk wads are indispensable, and those which are used wet should be of a low gauge. The shot also should be of a low gauge.

Utensils required for the Shot.

One furnace, or grate. *One moving tool.* *One scraper.*

One pair of tongs. *One poker.* *One rake.* *One shovel.*

One stand on which to place the shot in order to scrape them.

One shot bearer per gun.

Two tubs full of water, to soak wads, cool tongs, &c.

Two or three water buckets.

The furnace may be heated either with wood or coals, or a mixture of coal and coke, according to circumstances.

One gauge for shot.

Loading.

The powder must be in a good flannel cartridge, which must undergo the strictest examination, to see that there are no holes in it, lest in setting it home any grains should fall out. The gun should be slightly elevated.

Until the cartridge is placed in the bore, the loading proceeds as with cold shot. Over the cartridge is placed first, a dry, and then a damp wad: the whole is rammed home together by Nos. 2 and 3.

If the gun has to be fired at a depression, or low angle, a wad is rammed home over the shot.

ARTICLE VI.—MOLTEN IRON.

Shells of a peculiar construction, loaded with fluid iron, are used against objects which it is wished to set on fire.

The metal is poured in until it shows itself above the filling hole; it then receives a few blows with a hammer to flatten it, so as to present no obstruction to the rolling of the shell, if necessary. The shell is then turned with the filling hole downwards, and a wood bottom riveted on. For two or three minutes after filling, the shell may be readily handled, provided the man is supplied with a pair of founder's gloves, pieces of sand bag, &c. After that time it gradually heats until it becomes dark red, when a shot bearer is requisite.

On striking the object the shell either acts as an ordinary hot shot, or it breaks up, and scatters the iron.

The former result happens when about ten minutes or a quarter of an hour elapse between filling and firing, the latter when there is an interval of from one to five or six minutes only. The degree of fluidity of the metal, and its dispersion on striking, depend on the time it is allowed to remain in the shell.

The metal is run down in a cupola, by means of a fan blast worked by hand; the cupola is mounted on framing, supported on two 3′ 9″ wheels in front, and on two legs behind. Two ladders enable men to get on the top of the stage (forming a case for the fan) and charge the furnace.

With the cupola are furnished two ladles, two hangers, two tapping bars, two rakes, two clearing hoops, one clearing plate, one tapping hammer, and two small filling funnels.

The iron used should be, if possible, in small masses, such as old shot or shell.

ARTICLE VIII.—NAVAL SLIDES.

For the 68 pounder. } Four additional men are required, numbered
„ 10 inch guns. } 11, 12, 13, 14.
„ 8 inch of 65 cwt. Two additional men, numbered 11, 12.

These men are necessary in traversing; Nos. 11 and 12 coil up falls.

Four sets of luff-tackle are required, brought up by Nos. 2, 3, 4, 5;—Nos. 2 and 3 hook the moveable blocks of the running-up tackles to the eye-bolts, outside the cheek in front; Nos. 4 and 5 to the eyes on the levers at the rear chocks;—Nos. 4 and 5 hook the moveable blocks of the traversing tackles to the eye-bolts at the rear of the slide;—Nos. 11 and 12 hook the standing blocks to the eye-bolts, or bollards at the sides.

The loading is as before.

Article IX.—Guns, or Carronades on Depressing Carriages.

When, after being fired, the piece is to be loaded, it must be brought to such a position that the sponge may be clear of the ground, or sill of the embrasure. Short pieces are best suited for firing at great depression, as they are easily managed and quickly loaded.

Article X.—Exercise of Ten, and Eight-inch Howitzers.

The loading is as before described, except that No. 2, after sponging, reverses the sponge, and presses the projectile home. Should reduced charges be used as in ricochetting, they must be either lengthened with wads, or rammed home separately, and the same rule applies with all shell guns.

At the word "*Ready,*" the men step one pace from the merlon in order to be clear of the explosion, or if there be no merlon, Nos. 2 and 3 take an oblique pace to the rear.

Howitzers on perch-trail carriages are provided with friction levers, which bear on the naves of the wheels; and chocks also are fitted over the trucks, in order to check the recoil.

Article XI.—Exercise of Mortars on Standing Beds, and Ground Platforms.

The detachment files on to the mortar from the rear, as with guns firing over a low parapet. 2 and 3 halt in line with the muzzle; 4 and 5 the trunnions; 6 and 7 the rear of the bed. The front numbers close to the edge of the platform, the remaining numbers uncovering outwards.

13 and 10 inch Mortars.
1 N. C. officer and 9 men.
1. Points, and commands.

3, plants pointing rods; puts in cartridge; assists to put in shell; runs up, traverses.	2, sponges; assists to put in shell; runs up, traverses.
5, runs up, traverses.	4, attends the vent; runs up and traverses.
7, supplies 3 with cartridges; assists at his handspike, and fires.	6, hands sponge to 2; assists at his handspike; wipes shell.
9, assists to prepare and bring up shells, and puts them in.	8, supplies cartridges from the magazine; assists to prepare and bring up shells, and puts them in.

10, at the magazine,
With 8 inch mortars, 7 men only are required.

No. 1 points; commands; hands sponge to No. 2.

3, runs up, traverses, provides cartridges, and puts it in; plants pointing rods.

5, assists 8 to prepare shells; fires; runs up; and traverses.

6, prepares shells; brings them up; and puts them in.

2, sponges; traverses; runs up; wipes shell.

4, attends the vent; runs up, and traverses.

7, at the magazine.

With the smaller mortars, $5\frac{1}{2}$, and $4\frac{2}{5}$ inch, 3 men are sufficient.

The shells ought always to be deposited behind traverses raised for the purpose, or in other sheltered places, and one or two men, according to circumstances, should be appointed to scrape and clean them inside and out, and prepare them for the powder and fuzes.

The following stores are required for the service of Mortars.

One sponge to be placed on the right of the mortar, the sponge head to the front, and supported to keep it free from gravel.

One scraper for two mortars.

One cartridge. case, for bringing up the cartridge; or a paper or leather case, for loading when the powder is loose.

One beam hook, for 13 inch, *One pair of hand hooks,* for 10 inch.

One piece of cord, for 8 inch.

Four-handspikes, for 13, 10, and 8 inch. Two on each side of the platform, as directed for guns.

Two pointing-rods, or pickets. If for masonry parapet, set on a 2 inch plank, 4′ long.

One plummet with line, in charge of No. 1.

A piece of sheepskin or an empty sand bag for wiping the bottom of the shell; to be placed on the right of the sponge.

One quadrant,
One perpendicular, } for every four or five mortars.
One fuze engine,

One tube pocket.

One lanyard with hook, for friction tubes.

One set of priming irons. One filling funnel. One mallet.

Two setters. One centre bit. Chalk prepared.

Shells, of the calibre of the mortar, and also $4\frac{2}{5}$ inch for volleys, in boxes.

Pound shot, in boxes. Bottoms, for ditto. *Lanthorn.*

Fuzes. Mortar. One winch hammer. Carcasses.

Light balls. { Ground,
Parachute.

Square quoins, for friction tubes, 15°, 75°.

At the Magazine.

One budge barrel. One set of weights and scales.

One set of powder measures.

Cartridges, empty, worsted, *lbs., Scissors.*

The mortar is prepared for action on the same principle as guns are.

No. 1 commands, and regulates the charge of powder and length of fuze.

*Laying Mortars.**

Mortars are usually fired from behind parapets, the height of which prevents those in the interior of the battery from seeing the object fired at, unless they expose themselves. The mortar is, therefore, laid, not directly on the object, but upon two pickets, called *pointing rods*, which are placed in front of each mortar, and in the vertical plane, passing between the centre of the platform, and the object to be struck.

These pickets are formed of two ⅝ round rods of iron, of about two feet long. For masonry works they must be placed on a fir plank, of about one foot wide, four feet in length, three inches thick, and about six inches from each end. The plank should be fitted with a grummet or handle at each end. In earthworks two ramrods will answer for pointing rods.

Should there be no banquette, the rods must be placed on the top of the parapet.

Carcasses, and Light Balls.

When carcasses, or light balls are fired, the 13 and 10 inch are brought up in the same manner as shells; the 8, 5½, and 4⅖ inch in the palms of the hands. No. 2 wipes the bottom of the carcass, uncovers the holes, and loosens the priming.

Light balls, both ground, and parachute, are fired with very reduced charges.

Pound Shot, and Stones.

When pound shot, or stones are used, they are brought up in a box, or basket, to the front of the mortar, in the same manner as shells. The No. who brings up the cartridge, brings up a wooden bottom, which 3 places over the powder. Nos. 2 and 3 empty the shot into the mortar, and give the empty basket to 6.

ARTICLE XIII.—FIRING BY NIGHT.

To insure as accurate a fire as possible during the night, the following expedients have been adopted:—

For guns on garrison carriages.—A directing bar, or piece of timber, about a foot or eighteen inches longer than the platform, and four inches by six in thickness, is used. It has a hole at one end, through which a bolt is passed into the platform close to the hurter and in the object line. On this bolt the bar traverses. At equal distances from the axis or middle line of the carriage, two cleats are bolted under each axletree, at a distance from each other equal to the breadth of the bar, and the bar is passed under the carriage and fitted between these cleats. Holes are bored at the tail of the platform, for the reception of bolts, at distances from each other to suit the size of the bar. The gun is laid for the object during the day, and should the bar fall exactly between two holes, the bolts are put in, and the bar remains fixed. When, however, the bar covers a hole, the bolts are put into the nearest holes on each side, and small wedges driven in between them and the bar, in order to keep it in its place. The gun now requires nothing more after each round than to be loaded, run up, and fired; operations which are as easily performed by night as by day.

This arrangement is not suited to guns on rear chock carriages.

For Guns on travelling carriages.—The gun having been properly laid during the day, a bead, or piece of timber of a proper scantling is nailed or screwed to the platform, inside the felloe of each wheel, and parallel to the object line, and two shorter pieces are fastened in like manner outside of the cheeks of the carriage, at the trail.

By a proper application of the scotches, every description of traversing platform can be made available for night firing.

When the foregoing expedients cannot be resorted to, the platform and the carriage should be chalked in different places, and when the gun is run up, these chalk marks should be made to correspond. A lantern, in this case, is always required.

The elevating screw must also be clamped, or the quoins lashed.

For Mortars.

After the mortar has been accurately laid, a plank, thin enough to go under the running-up bolts without touching them, is placed against the outside of one of the cheeks of the bed, and nailed or screwed to the platform, and the mortar, after every round, run up to it. If a suitable piece of plank cannot be procured, the platform must be chalked close to the mortar bed.

PART III.

ARTICLE I.—SLEDGES

are constructed of beams 10 inches in depth, 6 inches in thickness, and 10 feet 3 inches in length, parallel to each other, at the distance of 1 foot 5 inches apart, and connected by wooden transoms. They are easily put together, and have been found of great service in small expeditions, in which recourse has been had to the Navy for ships' guns, to carry on operations on shore.

If the ground be of a marshy, or shingly nature, the under part of the sledge must be covered with planks to prevent mud, stones, &c., from accumulating in front of the transoms; and, if there be time, the under part of the side pieces should be shod with iron, to prevent them wearing away.

There is a narrow description of sledge, which is made use of to move guns along sally ports and similar narrow passages, and up the ramps of fortifications. Guiding ropes are made fast to the rear of the sledge, and manned towards the rear, crossing each other, so that the men haul upon that which is fixed to the side farthest from them.

ARTICLE III.—SLING CART.

This cart is used for moving heavy ordnance, not exceeding 65 cwt., on hard, level roads.

The cart weighs 15 cwt.

One non-commissioned officer and six men are required to work it. They are numbered as for gun drill.

Articles required with the cart:—

One sling, of six inch white rope, two fathoms long, with an eye splice at each end.

One sling tie.

One inch tarred rope, two feet long.

One prypole, fitted with a prypole rope, 2½ inch, three fathoms.

Two levers, six feet nine inches long, fitted with two lever ropes, two inch tarred, two fathoms long.

Two pawls.

Two common handspikes.

One piece of short skidding, 4½ feet long, five or six inches square.

The detachment halts about three yards (the position of "Detachment rear"), in rear of, and facing the cart, which is supposed to be provided with its stores—viz., the sling on the windlass, the handspikes and levers lashed to the prypole. The gun to be slung is on a short skid. No. 1 gives the words "Form the order of exercise," "right face—left wheel—quick march." The ranks open out; the front rank discovering the left wheel; the rear rank the right. They are halted at one pace from them.

Disposition, and Duties of the Men.

No. 1 attends to the pawls, and commands.

Left side.	*Right side.*
3 has charge of the left lever, and skids the gun when necessary.	2 has charge of the right lever, and skids the gun when necessary.
5 has charge of a handspike, assists 3 at the lever and skidding, and raises the weight when it is to be lashed.	4 has charge of a handspike, assists 2 at the lever and skidding, and raises the weight when it is to be lashed.
7 assists 3 at the lever, slings, and unslings the gun, and lashes it to the prypole.	6 assists 2 at the lever, slings, and unslings the gun, and lashes it to the prypole.

Words of command.—"Unlash. Slew the gun, raise the trunnion on the right. Halt, cast off. Back the cart. Fix sling to right of windlass. Overhaul, and sling gun. Heave in the slack. Work levers. Halt, out levers. Lash up the breech. Heave. Trap, and make fast. Lash levers, and handspikes."

Unslinging.

In Unslinging, each No. undoes what he has done.

Words of command.—"Prepare to unsling. Levers take purchase to lower. Bear down. Ease off. Unsling."

Slinging a Mortar.

A Mortar is slung with the muzzle towards the rear. It is slewed like a gun. The sling is then put on close to the trunnions.

Unslinging a Mortar.

See—Unslinging a Gun.

Slinging a Mortar Bed.

The windlass for raising Mortar beds is generally of a different construction from that of guns, being square in the middle, and cylindrical at each end. Both ends of the sling are put on the pins placed for that purpose on the square part of the windlass, which in this case bears the whole weight. The bed is slung with the front part towards the rear of the cart.

Unslinging a Mortar Bed

is just the reverse of slinging; each No. undoing what he had previously done.

ARTICLE IV.—SLING WAGGON.

The sling waggon weighs about 29 cwt., and is employed for moving heavy ordnance, standing carriages, and traversing platforms. It requires a detachment of one non-commissioned officer and eight men.

The following articles are required with the waggon :—

One sling of six inch white rope, 2½ fathoms long, and having an eye-splice at each end.

One sling tie of one inch tarred rope, two feet long.

One breech rope, or *carriage sling,* of 2½ inch tarred rope, six fathoms long.

Two levers, six feet nine inches long, fitted with

Two lever ropes, two inch tarred rope, 2½ fathoms each.

Two pawls.

Four common handspikes.

Two pieces of skidding, about four feet long, and six or seven inches square.

One pair of strong dragropes.

One wrench hammer.

The detachment is numbered in the usual manner, and takes post for exercise as at the sling cart.

Disposition, and Duties of the Men.

No. 1 attends to the pawls and commands, keys, and unkeys keep chain.

Left Side.	*Right Side.*
3 has charge of the left lever and skidding, scotches the wheels in rear.	2 has charge of the right lever and skidding, scotches the wheels in rear.
5 has charge of a handspike, assists 3 at the lever, scotches the wheels in front, fixes the carriage sling, if necessary.	4 has charge of a handspike, assists 2 at the lever, scotches the wheels in front, fixes the carriage sling, if necessary.

Left Side.	*Right Side.*
7 assists 3 at the lever, slings, and unslings the gun, lashes the breech, handspikes, and levers.	6 assists 2 at the lever, slings, and unslings the gun, lashes the breech, handspikes and levers.
9 assists in unlimbering, and limbering up, and fixes the breech rope.	8 keys, and unkeys the draught chain, and fixes the breech rope.

The whole assist to limber up, and unlimber.

Position of the gun, and carriage.—The gun is supposed to be lying on skids, and its carriage on one side, with its breast nearly in line with the breech.

The gun is slewed as at the sling cart exercise, and the waggon is run over it (the even numbers on the right side, and the odd on the left), until the axletree is over the trunnions and the perch over the breech. The handspikes, levers, and sling, as at the sling-cart exercise, The windlass is supposed to be pawled.

Words of command.—"Prepare to unlimber. Unlimber. Lower. Prepare to turn the gun-carriage over. Heave. Off trucks. Lift the rear of the carriage, and place the lever. Mount the carriage. Heave. Work levers. High enough. Out levers. Off sling. Raise the rear of the carriage. Out lever. Prepare to limber up. Limber up. Back the waggon. Scotch the hind wheels. Put on the trucks."—"Sling the gun, work levers," &c., *as in the Sling cart exercise.* "Prepare to raise the breech. Raise the breech. Trap, and make fast. Place stool bed, and quoin. Lash up levers, and handspikes."

Dismounting the Gun, and Carriage.

Words of command.—"Place skids, unlash, and scotch the wheels. Unlash the breech, Levers take purchase to lower. Bear down, ease off, unsling, *as before.*"

"Prepare to unlimber. Unlimber. Dismount carriage. Turn the carriage over. Limber up."

Slinging Howitzers.

A Howitzer is slung in the same manner as a gun.

The manner of mounting a howitzer carriage differs in one respect from that of mounting a gun carriage; the width of the axletree arms of a 10 inch carriage being nearly equal to the distance between the wheels of the sling waggon, it is necessary that the trucks be put on one at a time, the carriage being pinched as far as possible to the opposite side, in order to make room for the operation.

In consequence of the cheeks not having steps, the carriage, after having been mounted, requires to be lashed.

Slinging Mortars.

A 13 inch mortar, and its bed, require each a waggon for itself; but a 10, or an 8 inch mortar can be conveyed on its bed, by one waggon.

A 13 inch mortar, lying on skids, is slewed like a gun, the sling being passed round close to both trunnions, and a piece of short skidding put into the muzzle, by which to lash it to the perch. The muzzle is raised and secured in the same manner as the breech of a gun.

To place a 13 *inch Mortar on its Bed by a Sling Waggon.*

The sling waggon to which the mortar is attached is brought over the bed. A handspike is laid on the ground on each side of the bed, opposite the front of the fore transom; and, when the mortar is far enough back, a handspike is also placed under each trunnion, clear of the sling. The muzzle is then unlashed, the breech lowered, the sling taken off, the two handspikes on which the breech rests taken out, and the trunnions placed in their holes. A handspike is next laid on each side, opposite the dolphins, and the waggon is run forward, until the rear of the axletree is clear of the upper part of the face. The waggon is then unlimbered, and the wheels are then *well* scotched. The bight of the sling is then placed under the lower lip of the mortar, and the ends brought up in rear of the axletree, and hooked on to the windlass, which is worked in front, until the muzzle is high enough. The quoin is then put in, and the capsquares are replaced; after which, the sling is slackened, until the muzzle of the mortar rests on the quoin. The sling is then taken off, and the waggon is removed.

Slinging a 13 *inch Mortar Bed.*

The mortar bed is traversed, and the waggon backed over it, in such a manner that the front of the bed may be next the shafts. The front of the bed is then raised by passing the bight of the sling under the front horns, and heaving upon the windlass, until it is high enough to allow the sling to be passed through underneath it. In this position it is propped with a skid, or the quoin. The windlass is then turned backwards, the sling is slackened, and one end of it is unhooked and passed through underneath the bed, about two inches behind the centre of gravity, or in rear of the centre of the trunnion holes. The end is then brought up, and the eye is hooked on the windlass again; the same number of turns should be taken round each barrel. The windlass is then worked, and the bed raised to its proper height. The front part of the bed, which is still resting on the skid, is next raised by handspikes, by Nos. 2, 3, 4, and 5; 6 and 7 passing the ends of their ropes round the running up bolts and over the perch, where they are double manned by 8 and 9. The bed is then raised till the underside is horizontal; after which a second turn is taken round the running up bolts. The whole is then frapped, and made fast with a reef knot.

Slinging a 10, *or* 8 *inch Mortar, and Bed.*

Ten, or 8 inch mortars are not dismounted for slinging. Their quoins are taken out, and the mortar is laid on the front transom, with its muzzle to the front. All the other parts of the operation are the same as detailed in the preceding paragraph, except that the sling, in order that it may be under the centre of gravity of the load, must be passed under the bed, about two inches in *front* of the centre of the trunnions.

ARTICLE VI.—TRIANGLE GYNS.

There are two patterns, the 18 feet, and the 16 feet. The former are for general service; the latter are applicable only to mounting guns on travelling, or standing carriages, platform waggons, &c.

The rear of the gyn is the part where the windlass is fixed. The front of the gyn is the prypole.

One non-commissioned officer and 12 men can raise and work either gyn, and carry it very short distances; but if they are to be transported more than 10 or 12 yards, they should be placed in a hand cart.

The detachment is halted in line facing the rear of the gyn, or the windlass.

Words of command.—"Take post on the gyn, right-face, left-wheel, quick march." The ranks open out, the front rank covering the left cheek; the rear rank, the right. They are halted at one pace from the cheeks.

Stores required for the Service of the Gyns.

One fall, 3½-inch white rope, 96 feet long; but only 72 feet for the small gyn.

The windlass is similar to that already described for the sling waggon and sling cart.

Two levers and lever ropes.

One triple block.

One double block.

One sling, of six-inch white rope, of a length to suit the dimension of the gun, or other object which is to be slung.

One single lashing rope, 2½-inch, for slinging mortars.

One piece of spunyarn, three stranded, 1½ fathom long, for seizing the clinch of the fall.

One ditto, one fathom long, for seizing the stopper.

One fid, for slinging the gun; or,—

One short piece of skidding, for the same purpose, for slinging mortars and howitzers.

One hammer, and one wrench hammer.

Three trucks, or *small pieces of board*, four inches thick, with a hole in the centre of each, to receive the spikes of the feet of the gyn on soft ground. Handspikes laid upon the ground, and on each side of the several spikes, will answer this purpose.

One pair of dragropes.

With both patterns.

The gyn should be placed, if possible, on level ground.

Disposition, and Duties of the Men.

No. 1 commands.

Left side.	*Right side.*
3 has charge of the left lever, keys, and unkeys the left cap-square, runs the carriage up, or back.	2 has charge of the right lever, keys, and unkeys the right cap-square, runs the carriage up, or back.
5 assists 3 at the lever, runs the carriage up, or back.	4 assists 2 at the lever, runs the carriage up, or back.

Left side.	*Right side.*
7 assists 6 to pass the fall round the windlass, holds on next to him.	6 passes the fall round windlass, holds on the fall and makes it fast, eases off the fall, and lowers the gun.
9 holds on the fall behind 7, and coils it up.	8 holds on the fall behind 6.
11 reeves, and unreeves the triple block, if necessary, assists in slinging the gun, and steadies it on his own side.	10 reeves, and unreeves the double block, if necessary, assists in slinging the gun, and steadies it on his own side.
13 assists to work levers.	12 assists to work levers.

The whole of the numbers assist to carry the gyn and put it together. If the gyn is put together and raised, the detachment is marched on it from the position of *Detachments rear*, the front rank covering the left cheek, the rear the right.

The cheeks and prypole are laid down on opposite sides of the piece, or other object, and generally in rear of it; their tops pointing inwards and as near each other as possible.

4. *To raise a Gun, or other object, and to mount, and to dismount a Gun, or Howitzer, on, and from a standing Carriage; or to shift it from one Carriage to another.*

Words of command.—"Pass the fall round the windlass. Put on the sling, and hook the block. Fix the sling. (Fix the lashing, *to a Mortar, or other piece of ordnance with dolphins.*) (Fix the sling to a mortar bed.) Shift the fall to the right of the windlass. Haul taut. Work the levers. Heave. High enough. Out levers." *If necessary,* "Stopper, and shift the fall. High enough. Make fast the fall." If a Gun, or Howitzer is to be dismounted, the Carriage is now run from under, and the piece is lowered to the ground.

If a gun, or howitzer is to be mounted upon its carriage, or shifted from one carriage to another, the carriage (if any) from which it has been removed is run from under the piece, and that on which it is to be placed is run forward by the same numbers, until the trunnion holes are directly under the trunnions, ready to receive them when the piece is lowered.

ARTICLE VII.—GIBRALTAR GYN.

The Gibraltar gyn is used for mounting, and dismounting guns, and howitzers on, and from standing carriages in situations where a triangle gyn could not be conveniently used. It weighs 10¾ cwt., and can support three tons with safety.

The following stores are required for the service of the gyn:—

One fall, of 3½-inch white rope, eight fathoms long.

Two lashings for slinging the gun, of 2½-inch tarred rope, each twenty feet long.

One stopper, about 5½ feet long, of 2½-inch tarred rope, more than one-half plaited as a gasket.

One iron triple block, with brass sheaves, to which is attached a bar of iron 2½ feet long for suspending the gun, its ends turned up to prevent the slings slipping off.

Four common handspikes.

Two dragropes.

One non-commissioned officer and six men are allowed for working the gyn, numbered as usual.

The gyn is moved by means of dragropes hooked to the staples of the front, or rear axletrees by Nos. 6 and 7. It can be drawn over hard level ground by the working detachment of six men.

The rear of the gyn is the part where the windlass is fixed.

The detachment being formed a few paces in rear of the gyn, No. 1 gives the word, "Take post for exercise—To the right face—Quick march."—The detachment wheels to the left, and the ranks open out. Nos. 2 and 3 halt one pace in rear of their respective axletree arms. The whole one pace from each other, and covering.

Disposition, and Duties of the Detachment.

No. 1 commands.

Left side.	*Right side.*
3 runs the carriage up, or back, heaves round the windlass, assists 7 to sling the gun.	2 runs the carriage up, or back, heaves round the windlass, assists 6 to sling the gun.
5 runs the carriage up, or back, assists to hold on the fall, stoppers, and unstoppers it.	4 runs the carriage up, or back, holds on the fall, makes it fast, and lowers the gun.
7 reeves the tackle, slings, and unslings the gun at the chase, and steadies it.	6 reeves the tackle, slings, and unslings the gun near the first reinforce, steadies the gun, and overhauls the tackle.

Words of command.—"Prepare to place the gyn. Place the gyn (by hand, or by cross lifting). Reeve the tackle. Prepare to sling the piece. Sling the piece. Haul in the slack. Heave round the windlass. Halt, stopper the fall. Shift the fall. Halt."

The carriage having been run under the piece, or away from it, as may be required, the piece is lowered and cast loose, each number reversing the operations which he performed in lashing, and raising it.

Part V.—Mounting, and Dismounting Ordnance without a Gyn.

Article I.—Implements required for the Manœuvres.

The following implements will be required generally for the various operations:—

Handspikes.—Ash, six feet, bevelled; two of seven feet.

Levers.—Ten or twelve feet in length.

Fulcrums.—Elm; the best dimensions for general purposes are two feet long, one foot broad, and seven inches thick; handspikes are often used as fulcrums.

Skids.—Oak; for mounting, and dismounting guns by parbuckle should be about fourteen feet long and seven inches square; three fir planks, of 2½ inch, bolted together, will answer; their ends should be bevelled. A grummet is let into each end as a needle in moving the skid.

Parbuckling a gun from the *terreplein* on to the parapet, or, on to its carriage on a traversing platform, at one operation, requires skids of twenty feet long and eight or nine inches square. These skids are made of three 3-inch deals, breadth nine inches. They are bolted together firmly.

To parbuckle on a platform waggon, the waggon serving as an inclined plane requires two pieces of scantling, each ten feet long and four inches square, or four pieces of 2½-inch plank of the same length, and five inches wide, to strengthen the side pieces of the waggon.

Skids for mortars and their beds should be twelve feet in length, and eight inches square for the 13-inch mortar; six inches by seven for the 10-inch, and six inches square for the 8-inch.

These skids are kept together by iron bolts of one inch diameter, with shoulders and keys, so that when in use they are nearly at the following distances from each other:—

13	inch mortar . . .	3¼ inches.
	„ „ bed . .	11 „
10	„ „ mortar and bed .	3½ „
8	„ „ „ .	2½ „

Skids, oak (short) for placing across the cheeks of gun carriages, or side pieces of platform waggons, should be from two feet eight inches to three feet long, and of various scantling, from nine inches by six, to three inches square, fitted with grummet handles.

Props (oak) may be of any scantling, but not under five inches square, and two and a half to three and a quarter feet long.

Rollers (elm) ought to be in sets of three.

1st set	6 feet long	10 inches diameter, fitted with grummets.
2nd „	3 to 4 feet long	7½ inches in diameter.
3rd „	3 feet	
4th „	2½ „ „	5 „ „
5th „	2 „ „	
6th „	20 inches „	
7th „	14 „ „	

They ought to be concave, or hollowed out a little in the middle, to about the depth of a quarter of an inch.

Planks, for shifting guns from one carriage to another, should be of three-inch deal, about ten feet long, the general width of seventeen inches will do. When for shifting a gun from the parapet to a traversing platform, they ought to be two and a half inch oak plank, and about twelve or fourteen feet long. A bolt passes through the ends of each plank to keep it from splitting.

Quoins.—Two, three, or four common ones.

Wedges or scotches, of elm, for scotching wheels, or guns on skids,

&c., about nine inches long, five inches broad, and four inches at the butt end; others of twelve or fifteen inches long, five inches broad, and three, two, and one inch at the butt end.

Park pickets, of ash, shod and hooped with iron, four or six.

Heavy hammers.—Two.

Mauls.—Two.

Crowbars, if working in rock, four or six.

Parbuckles.—Four-inch rope, twelve fathoms long, with a hook at one end.

Lashings, single, 1 fathom
double, 2 „
triple, 3 „ long of 2-inch rope.

Dragropes, or rope for that purpose, from four to five fathoms long, with a hook at one end.

Luff tackles.—Two double and two single blocks, eight-inch; the falls each twelve fathoms of two and a half inch rope. Bothway's blocks are the best.

Straps are of various dimensions, some of three and a half inch rope and eight feet long, for mounting mortar beds; some for slewing, of 2½ inch, and for steadying.

Also *gaskets* for stopping falls, and selvages. *Spun yarn*, *spades*, and *pickaxes* are also necessary, according to circumstances.

ARTICLE VI.—TO DISMOUNT A GUN, BREECH FOREMOST, OVER THE TRAIL OF A TRAVELLING CARRIAGE, AND ALSO TO MOUNT IT.

1st.—*To Dismount the Gun.*

Two pieces of three-inch rope, each 6 fathoms long, or two sets of luff-tackles complete.

Three rollers, one of them the largest size, three feet long, the other two, five inches in diameter and thirty inches long; also, the *gun roller.*

Two dragropes. Two seven-feet handspikes, and eight or ten handspikes.

Three straps or selvages, or pieces of 3½*-inch rope, three fathoms long.*

The carriage is to be unlimbered and the wheels scotched, the stoolbed is raised, and the gun roller placed on it, and under the gun near the reinforce ring by No. 7; the gun is then *raised out of the trunnion holes*, and the trunnions made to rest on the points of handspikes placed in each trunnion hole by 6 and 7.

Words of command.—" Hook the tackles. Bear down the muzzle. Raise the muzzle, and lower the gun." *When the rollers require shifting.* " Hold on. Raise the breech (or the muzzle), &c., &c."

2nd.—*To Mount the Gun.*

Words of command.—" Raise the muzzle, and place ground roller. Back the carriage. Scotch the wheels. Hook tackles. Taut. Heave. *The gun is made to mount, shifting rollers, as necessary.*

" Halt: unhook, and cast off."

ARTICLE XXIII.—TO MOUNT, AND DISMOUNT MORTARS ON, AND FROM THEIR BEDS.

Six handspikes. Two dragropes. One wrench for old pattern beds. One hammer. Two blocks of wood, about 8 *inches long by* 4½ *inches square.*

Remove capsquares. The mortar is supposed to be lying vent upwards, breech towards the bed, the breast of which is towards the mortar.

Mounting.

Words of command.—" Raise the mortar on its muzzle. Heave, and haul. Run the bed up. Shift the dragropes. Heave, and haul. (*With old pattern beds, the mortar is now to be brought vertical.*)—" Bring the mortar vertical. Heave, and haul."

Dismounting.

The mortar, and bed must be heaved to the front, or rear of the platform, and dismounted on the ground. With Old pattern beds, the mortar is brought to a vertical position, and the capsquares taken off.

Words of command.—" Fix the dragropes. Heave, and haul."

ARTICLE XXVI.—TO MOUNT, AND DISMOUNT HOWITZERS.

The same general stores as before detailed for mounting guns.

To raise a 10 *inch Howitzer on its Muzzle.*

The howitzer is supposed to be lying on the ground, vent upwards.

1*st. With dragropes.*

Words of command.—" Prepare to raise the breech. Bear down. Ease off. Hook dragropes to the cascable. Prepare to lift. Heave, and haul."

2*nd. By means of the travelling carriage.*

The breech is raised as before, and a handspike, or piece of skidding, placed by No. 6, under the vent field, so that there may be space enough for a rope to be passed under the piece; the breast of the carriage is towards the muzzle of the howitzer.

Words of command.—" Run the carriage over the howitzer. Halt. Scotch the wheels. Fix the howitzer rope. Prepare to unlimber. Unlimber. Fix the guyropes. Lift the trail." *When it is nearly vertical,* " Hold on. Secure the howitzer rope. Prepare to limber up. Limber up. Unscotch the front of the wheels. Take a wheel purchase. Run the carriage forward." The howitzer rope is then cast off, and the piece is ready for mounting.

To mount a 10 *inch Howitzer on a travelling carriage.*

The howitzer being on its muzzle, the carriage with the capsquares removed, is run up to it perfectly square, and the wheels *well* scotched; it is then unlimbered, and the trail raised; when the trunnion holes are opposite to the trunnions:

Words of command.—" Halt. Push the howitzer on the carriage; (or take a purchase under the muzzle). Put on capsquares. Prepare to limber up. Limber up."

To mount a 10 *inch Howitzer on a standing carriage.*

The carriage is to be run forward, but only so near to the howitzer, that when the trail is lifted, the highest part of the trunnion boxes may be just clear of the trunnions, and the trunnion holes correspond with them.

Words of command.—" Scotch the trucks. Prepare to raise the trail. Lift. Halt. Push the howitzer on the carriage. Fix the dragropes. Heave, and haul."

To dismount a 10 *inch Howitzer from a travelling carriage.*

Words of command.—" Unkey the capsquares. Hook dragropes to the cascable. Haul the howitzer out of the carriage. Limber up. Run the carriage forward. Prepare to lower the howitzer. Push the howitzer over."

To dismount a 10 *inch Howitzer from a standing carriage.*

Words of command.—" Scotch the trucks. Prepare to raise the carriage. Heave, (or lift). Hook dragropes to the cascable. Haul the howitzer out,—(or raise the howitzer on its muzzle). Run the carriage back. Prepare to lower the howitzer. Push the howitzer over."

PART X.

ARTILLERY SERVICE, EAST INDIAN.

ORDNANCE, BRASS.

FIELD ORDNANCE.

Brass.	Nature of Piece.	Length.			Charge.		Shot; Shell.	
		In feet and inches.	In Calibres.	Weight.	Calibre.	Service.	Proof.	High guage.	Low guage.
		ft. in.		cwt. qr. lb.	inches.	lb. oz.	lb. oz.	inches.	inches.
Guns	9 Pr.	5 8·8	.	10 0 0	4·2	2 4	.	4·117	4·0
	6 Pr.	5 0·0	.	6 0 0	3·668	1 8	.	3·585	3·498
Howitzers	24 Pr.	4 0·0	.	10 0 0	5·66	2 0	.	5·63	5·54
	12 Pr.	3 9·2	.	6 2 0	4·52	1 4	.	4·47	4·4

MOUNTAIN ORDNANCE.

Brass.	Nature of Piece.	Length.		Weight.	Calibre.	Charge.		Shot; Shell.	
		In feet and inches.	In Calibres.			Service.	Proof.	High guage.	Low guage.
		ft. in.		cwt. qr. lb.	inches.	lb. oz.	lb. oz.	inches.	inches.
Gun . . .	3 Pr.	3 0·0	.	2 1 5	2·931	0 12	.	2·838	2·808
Gun Howitzers	12 Pr.	3 0·0	.	1 3 10	4·52	0 8	.	4·47	4·4
	9 Pr.	2 7·9	.	1 3 8	4·360	0 8	.	4·11	4·0
Howitzer .	4⅖-inch	1 10·0	.	2 1 4	4·52	0 8	.	4·47	4·4

Mountain Carriages.	Weight.			
	3 Pr. Gun.	9 Pr. Howitzer.	12 Pr. Howitzer.	4⅖-inch Howitzer.
	cwt. qr. lb.	cwt. qr. lb.	cwt. qr. lb.	cwt. qr. lb.
Carriage, or Bed	1 2 25	1 3 8	1 3 10	2 1 4
Limber, when used	1 2 14	1 2 14	1 2 14	1 2 14
Shafts, in lieu of Limber	0 1 10	0 1 16	0 1 10	0 1 10
Pole with Yoke for Bullocks . .	0 1 7	0 1 7	0 1 7	0 1 7

RANGE TABLES.

IRON, AND BRASS GUNS. ROUND SHOT.

Guns.	Iron.			Brass.			
Calibre . .	24 Pr.	18 Pr.	12 Pr.	12 Pr.	9 Pr.	6 Pr.	3 Pr.
	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.	Yards.
P. B. Range .	332	306	239	..	272	236	..
L. M. Range .	950	900	700	600	600	500	500
Range in Yards.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.	Deg.
300	P.B.	P.B.	⅛	⅛	⅛	¼	¼
400	¼	¼	¼	⅜	⅜	¾	¾
500	⅝	⅝	⅝	⅝	⅝	L.M.	L.M.
600	¾	¾	¾	L.M.	L.M.	1¼	1¼
700	⅞	1	L.M.	1⅜	1⅜	1⅝	1⅝
800	1⅛	1¼	1¼	1⅞	1⅞	2	2⅛
900	1⅜	L.M.	1¾	2⅜	2⅜	2½	2¾
1,000	1⅝	2	2	2½	2½	2¾	3½
1,100	..	..	..	2¾	2¾	3¼	4½

IRON, AND BRASS HOWITZERS. COMMON SHELL.

Howitzers.	Iron.				Brass.					
Calibre . .	10 Pr.		8 Pr.		24 Pr.		12 Pr.		4⅖-inch.	
	Yards.		Yards.		Yards.		Yards.		Yards.	
P. B. Range .	194		187		155		187		..	
L. M. Range .	194		187		155		187		..	
Range in Yards.	E.	F.	E.	F.	E.	F.	E.	F.	E.	F.
300	..	..	..	..	...	..	..	..	..	..
400	2¼	..	..	..	1	1½	1¼	2	2¾	5
500	2¼	3½	2¼	3½	1⅝	2¼	1⅝	3	4	6½
600	2¾	4½	2¾	4½	2¼	3¼	2¼	4	6	8
700	3⅛	5½	3⅛	5½	2¾	4½	2⅞	5	7½	9½
800	3⅝	6½	3⅝	6½	3⅝	5¾	3¼	6	10	11½
900	4	7½	4	7½	4	6¾	3¾	7	11	13
1,000	4⅞	8½	4⅞	8½	4¼	7¾	4¼	8	..	..
1,100	6½	9½	6½	9½	5¼	8¾	5	9	..	..
1,200	7	10½	7	10½	..	..	..	..	..	..
1,300	8	11½	8	11½	..	..	..	..	..	..
1,400	8¾	12½	8¾	12½	..	..	..	..	..	..
1,500	9	1·4	9	1·4	..	..	..	..	..	..

IRON GUNS. SHRAPNEL SHELL.

Calibre			24 Pr.		18 Pr.		12 Pr.	
Elevation, and Fuze . . .			Deg.	Tenths.	Deg.	Tenths.	Deg.	Tenths.
Bursting distance.	Effective.		Elev.	Fuze.	Elev.	Fuze.	Elev.	Fuze.
	From	To						
Yards.	Yards.	Yards.						
600	650	800	..	..	..	..	..	..
700	750	900	..	..	..	..	..	..
800	850	1,000	1½	3	1½	3	1¾	3
900	950	1,100	2	4	2	4	2⅛	4
1,000	1,050	1,175	2½	5¼	2½	5¼	2¾	5¼
1,100	1,150	1,275	3	5¾	3	5¾	3	5¾
1,200	1,250	1,350	3¾	6½	3¾	6½	3¾	6½
1,300	1,350	1,450	4¼	7¼	4¼	7¼	4½	7¼

BRASS GUNS, AND BRASS HOWITZERS. SHRAPNEL SHELL.

Guns, and Howitzers.	Brass Guns.				Brass Howitzers.	
Calibre . .	9 Pr.		6 Pr.		24 Pr. & 12 Pr.	
Range in Yards.	Elev.	Fuze.	Elev.	Fuze.	Elev.	Fuze.
400	1¼	1¾	1¼	2	1⅝	2¾
500	1¾	3	1¾	3	2	3¾
600	2⅓	3½	2¼	3½	2½	4¾
700	2½	4½	2¾	4½	2¾	5½
800	3	5½	3¼	5½	3	6¼
900	3½	6	3¾	6½	3¾	7
1,000	4	7	4¼	7½	..	..

IRON, AND BRASS MORTARS.

	Iron.									Brass.						Fuze Ins.	
	13 In.			10 In.			8 In.			5½ In.			4⅖ In.				
	Charge at 45°.																
Range in Yards.	lbs.	oz.	dr.	lbs.	oz.	dr.	lbs.	oz.	dr.	lbs.	oz.	dr.	lbs.	oz.	dr.	in.	ths.
300		..			..			..		0	2	13	0	1	8	1	5
350		..			..			..		0	3	4	0	1	10	1	6
400	1	10	0	0	14	0	0	8	12	0	3	6	0	1	13	1	8
450		..			..			..		0	3	8	0	1	14	1	9
500	1	15	0	1	2	0	0	10	0	0	3	10	0	2	0	2	0
550		..			..			..		0	3	10	0	2	3	2	1
600	2	4	0	1	4	0	0	12	8	0	4	1	0	2	6	2	2
700	2	8	8	1	6	0	0	14	0		..			..		2	3
800	2	14	0	1	8	0	0	15	0		..			..		2	4
900	3	2	8	1	10	0	1	0	0		..			..		2	5
1,000	3	7	8	1	12	0	1	2	0		..			..		2	6
1,100	3	11	8	2	0	0	1	3	0		..			..		2	7
1,200	3	14	0	2	2	0	1	4	0		..			..		2	9
1,300	4	2	0	2	4	0	1	6	0		..			..		2	10
1,400	4	6	0	2	7	0	1	8	0		..			..		3	1
1,500	4	10	0	2	9	0	1	9	0		..			..		3	2
1,600	4	15	0	2	11	0	1	13	0		..			..		3	3

RANGE PLATES.

GUNS.

6 Pr. F. P.		Ch. 1½ lb.				
Range.	Round Shot.	Canister.				
Yards.	Elev.	Elevation.				
100	P. B.	P. B.				
200	P. B.	½°				
300	¼°	1½				
400	¾	2				
		Shrapnel.				
		New Guns.		Old Guns.		
		Elev.	Fuze.	Elev.	Fuze.	
		Deg.	Inches.	Deg.	Inches.	
400	¾	1	·1½	1¼	·2	
500	L. M.	1¼	·2¼	1¾	·2¾	
600	1¼	1½	·2¾	2	·3¾	
700	1⅝	1¾	·3¾	2½	·4½	
800	2	2½	·4¼	3¼	·5¼	
900	2½	3	·5¼	3¾	·6¼	
1,000	2¾	3½	·6¼	4¼	·7¼	

Fuzes should burst 50 yards short. Old Guns require longer fuze, and more elevation.

GUNS.

9 Pr. F. P.		Ch. 2¼ lbs.				
Range.	Round Shot.	Canister.				
Yards.	Elev.	Elevation.				
100	P. B.	P. B.				
200	P. B.	½°				
300	⅛°	1½				
400	⅜	2				
		Shrapnell.				
		New Guns.		Old Guns.		
		Elev.	Fuze.	Elev.	Fuze.	
		Deg.	Inches.	Deg.	Inches.	
400	⅜	¾	·1½	1	·1¾	
500	⅝	1⅛	·2¼	1½	·2¾	
600	L. M.	1½	·2¾	2	·3¾	
700	1⅜	1¾	·3½	2½	·4½	
800	1⅞	2¼	·4¼	3	·5¼	
900	2⅜	2¾	·5	3½	·6	
1,000	2½	3	·5¾	4	·7	
1,100	2¾	..	..	..	..	

Fuzes should burst 50 yards short. Old Guns require longer fuze, and more elevation.

RANGE PLATES.

HOWITZERS.

12 Pr. Howitzer. Ch. 1¼ lb.

Range.	Common Shell.		Shrapnel.	
	Elevation.	Fuze.	Elevation.	Fuze.
Yards.	Deg.	Inches.	Deg.	Inches.
400	1¼	·2½	1⅜	·2
500	1⅜	·3½	2¼	·2¾
600	2¼	·4½	2¾	·3¾
700	2⅞	·5½	3	·4¾
800	3⅜	·6½	3½	·5¾
900	3¾	·7½	4¼	·6¾
1,000	4¼	·8½	..	..
1,100	5	·9½	..	..

Old Howitzers require longer fuzes, and more elevation.

Canister . { At and within 150 yards, P. B.
{ Add ¼° elevation for every 25 yards.

HOWITZERS.

24 Pr. Howitzer. Ch. 2 lb.

Range.	Common Shell.		Shrapnel.	
	Elevation.	Fuze.	Elevation.	Fuze.
Yards.	Deg.	Inches.	Deg.	Inches.
400	1	·2	1⅜	·2
500	1⅜	·2¾	2¼	·2¾
600	2¼	·3¾	2¾	·3¾
700	2¾	·5	3	·4¾
800	3⅝	·6¼	3½	·5¾
900	4¼	·7¼	4⅝	·6¾
1,000	4⅝	·8¼	..	..
1,100	5½	·9¼	..	..

Old Howitzers require longer fuzes, and more elevation.

Canister . { At and within 150 yards, P. B.
{ Add ¼° elevation for every 25 yards.

EQUIPMENT.

LIGHT, FIELD, INDIAN ARTILLERY.

Weight of Ordnance, Carriages, Limbers, Waggons, Charges, Ammunition, and Small Stores.

	GUNS.				HOWITZERS.			
	6 Pr.		9 Pr.		12 Pr.		24 Pr.	
		lb.		lb.		lb.		lb.
Ordnance	..	672	..	1,120	..	728	..	1,120
Carriage	..	1,421	..	1,560	..	1,464	..	1,520
Limber	..	1,266	..	1,266	..	1,266	..	1,266
Ammunition	32	189	24	214	20	182	16	291
Charges	..	61	..	72	..	41	..	46
Small Stores	..	124	..	124	..	124	..	124
		3,733		4,356		3,805		4,364
Waggon Body	..	1,482	..	,432	..	1,482	..	1,482
Limber	..	1,266	..	1,266	..	1,266	..	1,266
Ammunition	96	544	72	624	60	537	48	807
Charges	..	187	..	221	..	135	..	139
Small Stores	..	232	..	232	..	232	..	232
		3,711		3,753		3,544		3,818

EQUIPMENT.

SIEGE, OR HEAVY ORDNANCE.

Weight of Ordnance, Carriages, Limbers, Carts, Wheels, and Platforms.

		Iron Guns.									Iron Howitzers.					
		24 Pr.			18 Pr.			12 Pr.			10-inch.			8-inch.		
		cwt.	qr.	lb.	cwt.	qr.	lb.	cwt.	qr.	lb.	cwt.	qr.	lb.	cwt.	qr.	lb.
Carriage,	Garrison	16	2	23	14	3	10	13	2	26		..			..	
,,	Travelling	23	0	0	20	0	0	19	0	0	33	2	16	27	1	18
,,	Sling	24	3	26		..			..			..			..	
Limber for above*		11	0	0	11	0	0	11	0	0	11	0	0	11	0	0
Cart Platform (O. P.)†		8	1	24		..			..			..			..	
,, ,,	(N. P.)‡	11	0	16		..			..			..			..	
Wheels, one pair.	Sling Carriage	13	1	14		..			..			..			..	
	Heavy Ordnance	9	1	20		..			..			..			..	
	Limber ditto	5	3	24		..			..			..			..	
	Field Carriage	5	2	24		..			..			..			..	
	Mountain ditto	1	0	11		..			..			..			..	
Chest Laboratory	Empty	0	1	20		..			..			..			..	
	Filled	1	2	22		..			..			..			..	
Platform,	Skeleton, Gun	9	1	0	7	0	18	7	0	18		..			..	
,,	Gun, or Howitzer	21	0	0	21	0	0	21	0	0	21	0	0	21	0	0
,, ,,	Skeleton, Mortar, ,, 13-inch	14	2	1		..			..			..			..	
,, ,,	10-inch	8	3	20		..			..			..			..	
,, ,,	8-inch	8	1	16		..			..			..			..	

NOTE.—Coast Gun Equipment—same as in England.

* Same Limber for all; in India the low Limber is not used.

† Old pattern for Stores, &c., accompanying a Siege Train.

‡ New pattern for carrying the Garrison Carriage for Battery Guns.

PACKAGE OF AMMUNITION IN THE BOXES OF LIGHT FIELD ARTILLERY.

SIX-POUNDER GUN.

Gun, or Waggon Limber.

Near.

2 R.	2 R.	32 Fuzes. 1 Line, Seizing. 1 Cotton Match.	2 Cartouches. 2 Bursters. 16 Charges, filled. 2 Charges, empty.
2 R.	2 R.		
1 R. 1 C.	1 R. 1 C.		
1 S. 1 C.	1 S. 1 C.		

Off.

Same as Near.	Cartridges Priming 74. 1 Line, Seizing. 1 Match Slow.	2 R.	2 R.
		2 R.	2 R.
		1 R. 1 C.	1 R. 1 C.
		1 S. 1 C.	1 S. 1 C.

5 Portfires on each Lid.

Waggon Body.

Near Fore.

2 R.	2 R.	1 Line, Seizing. 1 Slow Match.	2 Cartouches. 2 Bursters. 16 Charges, filled. 2 Charges, empty.
2 R.	2 R.		
1 R. 1 S.	1 R. 1 S.		
2 R.	2 R.		

Off Fore.

Same as Near.			

Near Hind.

			Same as Near.

Off Hind.

Same as Near.			

Note.—R., Round; C., Case; S., Shrapnel.

NINE-POUNDER GUN.

Gun, or Waggon Limber.

Near.

1 S. 1 C.	2 R.	2 R.	32 Fuzes. 1 Cotton Match. 1 Line, Seizing.
1 S. 1 C.	2 R.	2 R.	
2 Cartouches. 2 Bursters. 12 Charges, filled. 2 Charges, empty.			

Off.

56 Cartridges. Priming 1 Match, Cotton. 1 Line, Seizing.	1 S. 1 C.	2 R.	2 R.
	1 S. 1 C.	2 R.	2 R.
2 Cartouches. 2 Bursters. 12 Charges, filled. 2 Charges, empty.			

4 Portfires on each Lid.

Waggon Body.

Near Fore.

2 Cartouches. 2 Bursters. 12 Charges, filled. 2 Charges, empty.			
1 R. 1 S.	2 R.	2 R.	1 Line, Seizing. 1 Match, Slow.
1 R. 1 S.	2 R.	2 R.	

Off Fore.

Same as Near.			

Near Hind.

Same as Near.			

Off Hind.

Same as Near.			

Note.—R., Round; C., Case; S., Shrapnel.

TWELVE-POUNDER HOWITZER.

HOWITZER, OR WAGGON LIMBER.

Near.

1 S. 1 Co.	70 Fuzes. 1 Match, Slow. 1 Line, Seizing.		1 S. 1 Co.
1 Co. 1 S.	1 Ca.	1 Ca.	1 Co. 1 S.
2 Cartouches. 8 Bursters. 10 Charges, filled. 2 Charges, empty.			

Off.

1 S. 1 Co.	46 Cartridges. Priming. 1 Match, Slow. 1 Line, Seizing.		1 S. 1 Co.
1 Co. 1 S.	1 Ca.	1 Ca.	1 Co. 1 S.
Same as Near.			

4 Portfires on each Lid.

WAGGON BODY.

Near Fore.

2 Cartouches. 10 Bursters. 10 Charges, filled. 2 Charges, empty.			
1 S. 1 Co.	1 S.	1 S.	1 S. 1 Co.
1 Co. 1 S.	1 Line, Seizing. 1 Match, Slow.		1 Co. 1 S.

Off Fore.

Same as Near.			

1 S. 1 Co.	1 Line, Seizing. 1 Match, Slow.		1 S. 1 Co.
1 Co. 1 S.	1 Car.	1 Car.	1 Co. 1 S.
2 Cartouches. 8 Bursters. 10 Charges, filled. 2 Charges, empty.			

Near Hind.

Same as Near Fore.			

Off Hind.

NOTE.—S. Shrapnel. Co. Common. Car. Carcasses. Ca. Case.

TWENTY-FOUR-POUNDER HOWITZER.

Howitzer, or Waggon Limber.

Near.

<table>
<tr><td>1 S.
1 Co.</td><td>1 S.
1 Ca.</td><td rowspan="2">54 Fuzes.
1 Line, Seizing.
1 Match, Slow.</td></tr>
<tr><td>1 S.
1 Co.</td><td>1 S.
1 Ca.</td></tr>
<tr><td colspan="3">2 Cartouches.
6 Bursters.
8 Charges, filled.
2 Charges, empty.</td></tr>
</table>

Off.

<table>
<tr><td rowspan="2">37 Cartridges Priming.
1 Line, Seizing.
1 Match, Slow.</td><td>1 S.
1 Co.</td><td>1 S.
1 Ca.</td></tr>
<tr><td>1 Co.
1 S.</td><td>1 Ca.
1 S.</td></tr>
<tr><td colspan="3">Same as Near.</td></tr>
</table>

3 Portfires on each Lid.

Waggon Body.

Near Fore.

<table>
<tr><td colspan="3">2 Cartouches.
8 Bursters.
8 Charges, filled.
2 Charges, empty.</td></tr>
<tr><td>1 S.
1 Co.</td><td>1 S.
1 Co.</td><td rowspan="2">1 Line, Seizing.
1 Match, Slow.</td></tr>
<tr><td>1 Co.
1 S.</td><td>1 Co.
1 S.</td></tr>
</table>

Off Fore.

<table>
<tr><td colspan="3">Same as Near.</td></tr>
<tr><td rowspan="2"></td><td></td><td></td></tr>
<tr><td></td><td></td></tr>
</table>

<table>
<tr><td>2 S.</td><td>1 Co.
1 Car.</td><td rowspan="2">1 Line, Seizing.
1 Match, Slow.</td></tr>
<tr><td>2 S.</td><td>1 Car.
1 Co.</td></tr>
<tr><td colspan="3">2 Cartouches.
6 Bursters.
8 Charges, filled.
2 Charges, empty.</td></tr>
</table>

Near Hind.

<table>
<tr><td rowspan="2"></td><td></td><td></td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="3">Same as Near Fore.</td></tr>
</table>

Off Hind.

Note.—S. Shrapnel. Co. Common. Car. Carcasses. Ca. Case.

PACKAGE, AND STOWAGE OF SMALL STORES.

STOWAGE OF SMALL STORE BOX—GUN.

Same exactly for 6, 9, 12, and 24 Pounders, with the slight exception noted below.*

Augers, fuze, hand, with bits	1	Mallets, fuze	1
Bits, gun	1	Pincers, fuze	1
Compasses, brass	1	Rasps, flat	1
Corkscrews, iron folding	1	Saws, dovetail, or fuze	1
Esses, iron	1	Setters, fuze	2
Files, saw	1	Spikes, jagged	1
Funnels, copper	1	Spikes, spring	1
Hammers, wrench	1	Wires, priming	1
Knives, laboratory	1	Worms, gun	1
Line, seizing . . . pieces	4	Wrenches, fuze	1

STOWAGE OF SMALL STORE BOX—WAGGON.

Same exactly for the 6, 9, 12, and 24 Pounders.

Cases, tin, for quick match		1
Esses, iron		1
Line, rat	skeins of 10 yards	2
Line, seizing	pieces of ,,	4
Telescopes, folding		1—⅙ to a Battery.
Vices, smith, bench, small		1
Wax-cloth	yards	4

STOWAGE OF IMPLEMENTS, AND SMALL STORES, SHOWING WHERE PLACED, OR LASHED.

Aprons, gun, canvas	1	On the gun.
Augers, fuze, hand, with bits	1	Store box, gun.
Axes, pick, Europe, with helves	1	Front foot-board, waggon; helves between boxes.
Bits, gun	2	Rt. cheek, 1; Store box, gun, 1.
Boxers, fuze	½	½ to each store box, waggon.
Boxes, fuze, tin	2	Store box, waggon.
Buckets, gun	2	1, breast-hook; rear of waggon, 1.
Callipers, gunners'	⅓	Store box, howitzer.
Caps, sponge, canvas	2	On the sponges.
Cases, tin, quick match	1	Store box, waggon.
Colours, camp	4	Camp colourman.
Compasses, brass	1	Store box, gun.
Corkscrews, iron folding	1	Store box, gun.
Dragropes, L. O. . . . . pairs	2	1 pair in rear of each limber axle.

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* Calliper, brass, small, or gunner 1 } Carried in howitzer, but not in gun
Scales, brass gunner, 1 foot . . 1 } small store box.

Drifts, gun, or vent	1	Right cheek.
Esses, iron, of sorts	2	Store box, gun, 1; store box, waggon, 1.
Files, saw, of sorts	1	Store box, gun.
Funnels, copper, 3rd class	1	Store box, gun.
Hammers, claw	1	Right cheek.
Hammers, wrench	1	Store box, gun.
Handspikes, common	1	Between waggon boxes.
Hatchets, hand	1	Left cheek.
Hoes, Europe, large, with helves	2	Front foot-board, waggon.
Knives, laboratory	1	Store box, gun.
Line, seizing, 10 yards	8	Store box, gun, and waggon.
Line, rat, 10 yards	2	Store box, waggon.
Locks, pad, brass, small	10	On the boxes of gun, and waggon.
Mallets, fuze	1	Store box, gun.
„ park	2	1, between boxes, on each limber.
Match, quick lb.	⅓	In tin case.
Oakum	..	As required.
Pawlin, gun and limber	⅙	First store cart.
Pincers, fuze	1	Store box, gun.
Poles, limber, L. O.	1	For each carriage, if fitted for bullock draft.
Rasps, flat, 8 in.	1	Store box, gun.
Reels, camp, with line	1	Camp colourman.
Saws, dovetail, or fuze	1	Store box, gun.
Scales, brass, gunners	⅓	Store box of howitzer only.
Setters, fuze	2	Store box, gun.
Shafts, limber, complete, pair	½	Under waggons.
Sockets, portfire	1	Left cheek.
Spikes, gun, jagged	1	Store box, gun.
„ spring	1	Store box, gun.
Sponge, with rammer	2	1 above, and 1 under the trail.
Straps, leather, side-arm	..	As required,
Telescopes, 2½ ft. folding	⅙	Store box, waggon.
Tilts for cart, spare	⅙	2nd store cart, with tools.
Traces, chain, L. O. pole.	..	1 pair, carriage; 1 pair, cart.
„ „ leading	..	4 pairs, carriage; 1 pair, cart; ⅙, spare.
Vices, smith, bench, small	1	Store box, waggon.
Wax-cloth yards	4	Store box, waggon.
Wires, priming, cannon	2	Rt. cheek, 1; store box, gun, 1.
Worms, gun, N. P.	1	Store box, gun.
Wrenches, fuze, brass	1	Store box, gun.
Yokes, pole, double	..	1 pair, carriage; 1 pair, cart; ⅙, spare.
„ trace, or leading, double	..	4 pairs, carriage; 1 pair, cart; ⅙, spare.

PART XI.

GUNNERY.

By the Parabolic Theory, the greatest range is when the angle of elevation is 45°, or half a right angle; and the ranges are equal at angles, equally above, and below 45°. In projectiles, moving with velocities not exceeding 300 or 400 feet per second of time, the Parabolic theory will resolve cases tolerably near the truth; but in cases of great projectile velocities, that theory is quite inadequate, without the aid of data, drawn from good experiments; for so great is the effect of the resistance of the air to projectiles of considerable velocity, that some of those, which in the air range only two or three miles, would, in vacuo, range between twenty and thirty miles. The effects of this resistance are also various, according to the velocity, the diameter, and the weight of the shot.

By experiments it will be found that the greatest range (instead of being constantly that at an elevation of 45°, as in the Parabolic theory), will be at all intermediate degrees between 45° and 30° (with ordinary charges about 42°), being more, or less, both according to the velocity, and the weight of the projectile; the smaller velocities, and larger shells ranging farthest when projected almost at an elevation of 45°; while the greatest velocities, especially with the smaller shells, range farthest with an elevation of about 30°. However, as sufficient experiments have not yet been made to establish true rules for practical gunnery, independent of the Parabolic theory, we must at present content ourselves with the data of some one certain experimental range, and time of flight at a given angle of elevation, and then, by help of these, and the Parabolic theory, we can determine the like circumstances for other elevations that are not greatly different from the former, assisted by the following rules:—

PRACTICAL RULES IN GUNNERY.

1.—*To find the Velocity of any shot, or shell.*

It has been found by experiments, that with shot of mean windage, and powder of mean strength, a charge of one-third of the weight of the ball gives an initial velocity of about 1600 feet per second: therefore, *to find the velocity given by any other charge*, divide three times the weight of the charge by the weight of the ball, and multiply the square root of the quotient by 1600, the product will be the velocity in feet, or the space the shot passes over in the first second.*

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* By the ballistic experiment, conducted in May, 1837, it was found that, with a heavy 6-pounder gun, a charge of 1½ lb. gave a velocity of 1740 feet,

2. *The first graze, with given elevation, and charge, being known, to determine the Charge for any other first graze, and elevation.*

Multiply the known charge, and elevation into the proposed first graze, also the proposed elevation into the known first graze, and divide the first product by the last, for the charge required in ounces.

3. *Given the range for one charge, to find the Range for another charge, or the Charge for another range.*

The ranges have the same proportion as the charges; that is, as one range is to its charge, so is any other range to its charge, the elevation of the piece being the same in both cases.

Table of Velocities, &c., of shells.

Nature of shells, in inches	13	10	8	5½	4⅖
Their weight (loaded) in pounds .	200	92	46	16	8
Charge of powder (land service) do.	5	3	2	1	½
The velocities	436	500	629	693	693

From Experiments on the velocities of shot, the following results have been obtained:—

1. *The time of a ball's flight is nearly as the range*, the gun, and elevation being the same.

2. *The velocities decrease as the distances increase* (arising from the resistance of the air, which opposes the progress of the shot,) in a proportion somewhat higher than the squares of the velocities throughout, and subject only to a small variation.

3. *Very little advantage is gained, in point of range, by increasing the charge* more than is necessary to attain the object, the velocities given by large charges being very soon reduced to those by moderate charges; those, for instance, given by half the shot's weight are reduced to an equality with those by one-third, after passing through a space of only 200 feet. (*Vide* 8.)

4. *Very little benefit is derived from increasing the length of guns*, the velocity given by long guns of 22 calibres being reduced to an equality with that of short guns of 15½ calibres with similar charges, after passing through the following spaces—viz.:—

With ½ the shot's weight, about	285
" ⅓ do. do.	200
" ¼ do. do.	150
" ⅙ do. do.	115

5. *The resistance of the air* against balls of different diameters with equal velocities, is very nearly in the proportion of the squares of their diameters, or as their surfaces.

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and a charge of 2 lb. a velocity of 1892 feet per second. The shot employed were of a high gauge, windage only ·078 inch, and the powder was of the strongest quality; the weight of the pendulum fired into was 58 cwt. 3 qrs. 16 lb. A light 6-pounder, two feet shorter than the heavy 6-pounder, with similar charges, gave velocities of about 190 feet less.

6. *A very great increase of velocity may be acquired by a decrease of windage,* from $\frac{1}{3}$ to $\frac{1}{4}$ being lost by the windage of $\frac{1}{20}$ the diameter of the bore.

7. *By firing the charge in different parts* (separately, or simultaneously), by compressing the charge, by the use of wads, by varying the weight of the gun to lessen the recoil, or even by stopping the recoil entirely, no sensible change is produced in the velocity of the ball.

8. *The velocity increases with the charge,* to a certain point, peculiar to each gun; but, by further increasing the charge, the velocity gradually diminishes; yet the recoil is always increased by an increase of charge. (*Vide* 3.)

9. *The velocities of balls fired with equal charges* increase to a certain point, when the gun is longer, in a proportion which is nearly the middle ratio between the square and cube roots of the length of the bore.

10. *When shot of different weights are fired with the same charges of powder,* the velocities communicated to them are nearly in the inverse ratio of the square roots of their weights. Therefore, shot which are of different weights, and impelled by the firing of different charges of powder, acquire velocities which are directly as the square roots of the charges of powder, and inversely as the square roots of the weights of the shot. By making use of shot of a heavier metal than iron (lead for instance) the momentum of the shot discharged with the same charge of powder would be increased in the ratio of the square root of the shot's weight, which would both augment the force of the blow with which it would strike, and also the extent of the range.

Compound-shot, or shells filled with lead, fired with charges increased $\frac{1}{8}$th, will increase the power of range considerably.

11. *With common shells at* 45° *elevation, the time of flight* is nearly equal to the square root of the range in feet, divided by 4; or, more nearly, equal to the square root of the quotient of the range in feet, divided by $16\frac{1}{12}$.

12. *The range at* 45° *elevation* is nearly equal to the square of the time of flight in seconds, multiplied by $16\frac{1}{12}$ feet. The range at 15° will be about half that at 45°.

13. *Upon inclined planes, at any elevation,* there are always two elevations with which any range may be obtained.

The elevation which gives the greatest range, on a given ascent, is equal to half the sum of 90° added to the ascent.

The elevations which give equal ranges on a given ascent, are the complements of each other added to the ascent.

The elevation which gives the greatest range on a descent, is equal to half the complement of the descent.

14. *The depths penetrated by balls of the same size into wood,* with different velocities, or charges, are nearly as the squares of the velocities. Balls of different sizes will penetrate to depths proportionate to their diameters: therefore a greater ball will not only make a

larger hole, but will also penetrate farther than a small one with the same velocity.

15. By experiments at a mean range, it has been ascertained that in common earth, dug up, and well rammed, a musket ball buries itself nearly 1½ foot; a 6-pounder from 3½ feet to 4½ feet; 9-pounder from 6½ feet to 7 feet; 12-pounder from 8½ feet to 10 feet; 18, and 24-pounders from 11½ feet to 13 feet.

NAVAL GUNNERY.

INSTRUCTIONS FOR THE EXERCISE, AND SERVICE OF GREAT GUNS, ON BOARD HER MAJESTY'S SHIPS.

Every ship should be prepared to defend herself when attacked, on both sides. On assembling at quarters for action, or exercise, the men are to repair to their respective sides according to their watches, providing and distributing the several articles allotted them.

The first captains, and half the crew of the guns (the men designated by the odd numbers), remain by their proper guns; the second captains, and the remainder (designated by the even numbers), man the guns on their right.

Stationary powdermen are allotted to every two guns: they are to have two cases; that containing the reserve cartridge is to be *hung up* in rear of the gun amidships.

An extra powderman, whose duty it will be to fetch powder from the magazine scuttle, and supply the stationary powderman, is to be allotted to every four guns, that the reserve cartridge may not at any time be left without protection.

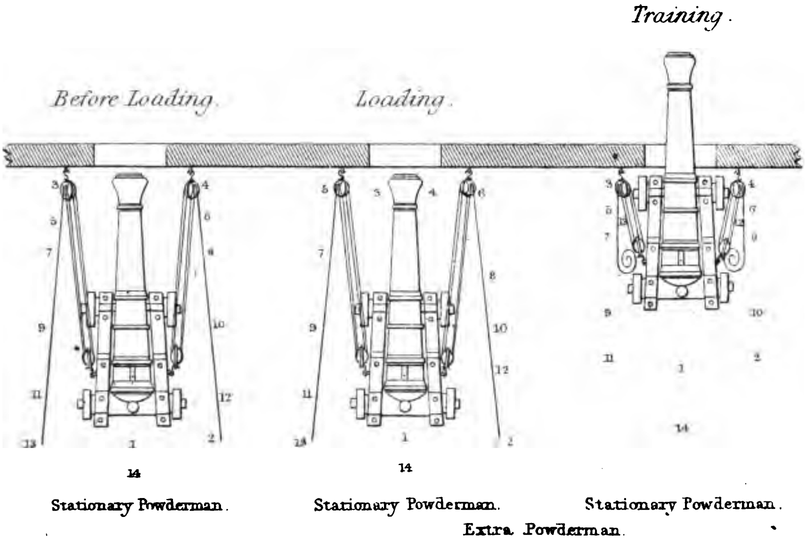
The gun and its opposite should bear the same number, beginning from forward with No. 1 on each deck.

The men appointed to work the gun are to be distinguished by numbers, which will be assigned according to the complement of men stationed at each gun, as hereafter described.

The crews and powdermen of the odd-numbered guns should be composed entirely of the starboard-watch, and the even-numbered guns of the port-watch; this will enable whole guns' crews to be worked together in their watch on deck, without disturbing the watch below, and will also enable the commanding officer to take the best men from both watches for the captains of the guns; they should be selected as much as possible from various parts of the ship, so that if a heavy loss of men should occur at particular guns, it would not be more severely felt at one station than at another. Petty officers, or leading men of stations, who are likely to be called upon in action to perform duties as such, are to be quartered at the guns nearest their work.

In assigning the duties, it is premised that the complements of all classes of Her Majesty's ships, small vessels excepted, will admit of the crew of each gun being composed of six persons and the powderman (the latter of whom is not to bear a number), by whom the principal duties in the working and providing for a gun are performed; the

POSITIONS.



J.W. Lowry, fc

first six are to be distinguished as the Gun numbers, and any additional men which its size may require, are to be considered as Auxiliaries, but they are to be equally instructed and rendered competent to perform the several duties of the gun. By this arrangement, one system will be applicable to the working of all the different natures of guns used at sea.

POSITIONS.

The crew, with the exception of the first and second captain and powdermen, are to stand with their faces turned obliquely towards the gun and the port, this position being best adapted to secure attention.

The two men whose numbers place them farthest from the ship's side, are to be termed right, and left rear men. The guns on each deck are to be divided into two divisions, called the foremost, and after quarters; and an officer is to be appointed to command each.

Arrangements are to be made in the different magazines and passages, for the regular supply of powder to the several decks, under the superintendence of an officer, to prevent confusion from the intermixture of the cartridges; and the following rule should be observed in supplying the different decks with powder, namely:—

In frigates, and two-decked ships, the lower, and main deck should be supplied from the fore magazine; and the quarter deck, and forecastle from the after magazine.

In three-decked ships, the lower, and middle deck from the fore magazine; main deck, quarter deck, and forecastle from the after magazine.

The fire screens are to be kept fixed, rolled up, and protected from the weather.

NOTE.—The above arrangement refers to Magazines as at present fitted.'

ASSEMBLING AT QUARTERS.

The accustomed beat of the drum is for Action; the stationary powdermen repair to the magazine-scuttle for two cartridge-cases and two cartridges, and then return to their places in the rear of their guns amidships, ready to receive all further supply of powder from the extra powderman.

The Gun numbers provide the stores, and with the Auxiliaries cast loose their respective guns, which are to be searched, loaded with full charges, and single shot, and run out without further orders: but they are on no account to be fired without *distinct* orders from the upper deck.

NOTE.—The above arrangement, although it insures the guns being got quickly ready for action, does not preclude the commanding officer from giving orders on beating to quarters, to load with any other charge or projectile he may think best.

The accustomed beat of the drum with one roll is for Manual exercise, the same as for Action, but no powder is provided.

The accustomed beat of the drum with two rolls is to muster for inspection: the crews and powdermen repair to their respective sides, unless ordered to the contrary. The stationary and extra powdermen take their places in the rear of their guns amidships. "Fall Out."

DETAIL FOR PLACING THE MEN.

Take your place in the rear of the gun facing the port, as No. 1, the captain.

Take your place to the right of the gun close to the ship's side, as No. 4, the sponger, standing quarter-face to the gun.

Take your place to the left of the gun close to the ship's side, as No. 3, the loader, standing quarter-face to the gun.*

Take your place to the right of the gun next to No. 4, as No. 6, the assistant sponger.

Take your place to the left of the gun next to No. 3, as No. 5, the assistant loader.

Take your place to the right of No. 1, facing the ship's side, clear of the recoil, as No. 2, the second captain.

These six numbers are Gun numbers, and provide stores for, and cast loose, this gun and the gun on the right in their respective watches. All numbers above these are Auxiliaries, who cast loose this gun and the gun on the right in their respective watches.

Take your place to the left of the gun next to No. 5 as No. 7.
" right " No. 6 as No. 8.
" left " No. 7 as No. 9.
" right " No. 8 as No. 10.
" left " No. 9 as No. 11.
" right " No. 10 as No. 12.

And so on with higher numbers. "Close up."

"Gun Numbers."
1, 2, 3, 4, 5, 6.
"Auxiliaries."
7, 8, 9, 10, 11, 12, 13, 14, &c.
"Handspikemen."
9, 10.
"Rear-men."
14. The right rear-man. 13. The left rear-man.
(Or the two highest numbers.)

Gun numbers as placed in rotation on arriving at the gun:—

1. The captain.
4. The sponger.
3. The loader.
6. The assistant sponger.
5. The assistant loader.
2. The second captain.

NOTE.—The Gun numbers are never to be called unless ordered; and when so ordered, Auxiliaries, Handspikemen, Rearmen, and 1, The Captain, &c., are to be called.

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* This order applies to all Nos. but 1 and 2.

MANNING BOTH SIDES.

MAN BOTH SIDES. Each watch will repair to its respective side, the odd numbers standing to the left of the left guns; even numbers to the right of the right guns.

Left guns,	3	remains	3	Right guns,	4	remains	4
	5	becomes	4		6	becomes	3
	7	„	6		8	„	6
	9	„	5		10	„	5
	11	„	2		12	„	2
	13	„	7		14	„	7
	1	remains	1		2	„	1

NOTE.—The left guns are odd starboard, and even port. The right guns are even starboard, and odd port.

Guns' crews always man, and powder-boys always supply adjacent guns, when clearing for Action, or when fighting both sides.

With a crew of 11 men and upwards, and both sides manned, 2 is *always* to attend the train-tackle.

PROVIDING STORES
(*both sides manned*).

No. 1. Provides 3 vent plugs, priming wire, tube box, spare trigger line, vent bit, sees the lock fixed and fit for use, and places handspikes.

3. Shot, and grummet, spare breeching, wet swab, wads, and fuze wrench.

4. Sponge, rammer, worm, and fire-bucket.

Stationary and extra powderman, two cartridge cases and two cartridges each.

NOTE.—With 68-pounders, and 10-inch guns, 3 should provide a bearer, and 4 should assist him in providing shot. Spare locks, and hammers are to be provided by the 2nd captain. Lanterns should be hung up amidships between the ports, and kept in order by the proper No. 4, arrangements being made for lighting them at night quarters.

Shells are always to be provided by the two highest numbers.

"MAN THE STARBOARD, OR PORT GUNS."

EXERCISE WITH 14 MEN TO A LOWER, MIDDLE, OR MAIN DECK GUN.

No. 1. The captain; commands, attends the breeching, primes, points, fires, and stops the vent.

2. The 2nd captain; assists 1, runs out, attends handspike, coin, and lock.

3. Loads, rams home, runs out, and trains.

4. Worms, sponges, rams home, runs out, and trains.

5. Gives shot and wad to 3, runs out, trains, and spans the breeching.

6. Gives sponge, rammer, and worm to 4, runs out, trains, and spans the breeching.

7 and 8. Run out, and train.

9 and 10. Run out, and attend handspikes.
11. Runs out, and attends handspike.
12. Runs out, and trains.
13. Runs out, trains, and brings up shell.
14. Attends train-tackle.

NOTE.—With more, or less than 14 men, the Exercise will be the same as above, except that the proper handspikemen will take the duties of 9 and 10, the assistant handspikemen, those of 11 and 2, and the rearmen, those of 13 and 14.

The captain of the gun is responsible that all stores and necessary gear are at the gun, and that throughout the Exercise all the Nos. perform their duties correctly.

EXERCISE WITH 9 MEN TO AN UPPER DECK GUN.

No. 1. The captain; commands, attends the breeching, primes, points, fires, and stops the vent.

2. The 2nd captain; assists 1, attends the apron, elevating screw, lock, and train tackle.

3. Loads, rams home, runs out, and trains.

4. Worms, sponges, rams home, runs out, and trains.

5. Gives shot and wad to 3, runs out, trains, and spans the breeching.

6. Gives sponge, rammer, and worm to 4, runs out, trains, and spans the breeching.

7 and 8. Run out, and attend handspikes.

9. Runs out, trains, and brings up shell.

NOTE.—With guns mounted on rear chock carriages having side levers for running out, Nos. 7 and 8 will shift the side tackles, and the left rearman will attend roller handspike when necessary.

With guns mounted on Hardy's carriages, the exercise will be the same as above, except that No. 4 will attend compressor when the gun is *out*, and No. 8 when the gun is *in*.

Handspikemen with 5, 6, or 7 men . .	5 and 6
,, ,, 8 or 9 men . .	7 ,, 8
,, ,, 10 or 11 men . .	7 ,, 8
and assistant handspikemen	9 ,, 2
Handspikemen with all Nos. above 11 .	9 ,, 10
and assistant handspikemen	11 ,, 2
Except with 10-inch, and 68-pounder guns, when assistant handspikemen will be .	11 ,, 12

With light guns it may be advantageous in some cases to double man the handspikes. The left rearman will always fire with a hammer, or match, and the right rearman will attend the train-tackle, except when he is handspikeman (when 2 will attend it) and in lower deck exercise (when *both* rearmen will attend it).

ASSEMBLING AT QUARTERS.

The accustomed beat of the drum is for Action, when the guns are to be cast loose, loaded, and run out without orders.

The accustomed beat of the drum with *one roll* is for Manual Exercise the same as for action, but without powder.

The accustomed beat of the drum with *two rolls* is to muster for Inspection.

Gun Nos., 1, 2, 3, 4, 5, 6.
Auxiliaries, 7, 8, 9, 10, 11, 12, 13, 14, &c.
Handspikemen, 9, 10. Rearmen, 14 the right rear-man, 13 the left rear-man (*or the two highest Nos.*).
1. The Captain. 4. The Sponger. 3. The Loader.
6. The Assistant-Sponger. 5. The Assistant-Loader.
2. The Second Captain.

MAN BOTH SIDES.

Left Guns—3 remains 3; 5 becomes 4; 7, 6; 9, 5; 11, 2; 13, 7; 1 remains 1.

Right Guns—4 remains 4; 6 becomes 3; 8, 6; 10, 5; 12, 2; 14, 7; and 2, 1.

PROVIDING STORES.

(*Both sides manned.*)

No. 1.—Provides 3 vent-plugs, priming wire, tube box, spare trigger-line, vent bit, sees the lock fixed and fit for use, and places handspikes.

No. 3.—Shot, and grummet, spare breeching, wet swab, wads, and fuze wrench.

No. 4.—Sponge, rammer, worm, and fire bucket.

Stationary and extra Powderman, two cartridge cases and two cartridges each.

Note.—With 68-pr., and 10-inch guns, 3 should provide a bearer, and 4 should assist him in providing shot. Spare locks, and hammers are to be provided by the 2nd Captain. Lanterns should be hung up amidships between the ports, and kept in order by the proper No. 4, arrangements being made for lighting them at night-quarters. Shells are always to be provided by the two highest Nos.

Stations for Casting loose a Lower deck Gun with 7 men.

(*Both sides manned.*)

Note.—No. 1 places handspikes, 3 and 4 bear out, and the other Nos. trice up the port; when the port is up, 1 provides stores, 2 and 7 cast off, and hook on train-tackle, 3 and 4 cast off muzzle-lashing, then provide stores and clear away breast-frapping, 5 and 6 clear away and shift side-tackles; when the side-tackles are clear, and train-tackle to the rear and luff choked, 1 gives the word "Elevate," sees the bed properly secured, and places coin at P. B., the gun is then run in, searched, loaded, and run out. While the gun is being elevated, 2 and 7 finish whatever is left undone, and whilst loading, 2 coils up the lashings, and 5 and 6 span the breeching.

MAN THE STARBOARD OR PORT GUNS.

GREAT GUN

The men are only to learn the Exercise

Nos.	Exercise with 14 Men to a Lower, Middle, or Main Deck Gun.
1	The Captain; commands, attends the breeching, primes, points, fires, and stops the vent.
2	The 2nd Captain; assists 1, runs out, attends handspike, coin, and lock.
3	Loads, rams home, runs out, and trains.
4	Worms, sponges, rams home, runs out, and trains.
5	Gives shot, and wad to 3, runs out, trains, and spans the breeching.
6	Gives sponge, rammer, and worm to 4, runs out, trains, and spans the breeching.
7 & 8	Run out, and train.
9 & 10	Run out, and attend handspikes.
11	Runs out, and attends handspike.
12	Runs out, and trains.
13	Runs out, trains, and brings up shell.
14	Attends train tackle.

Note.—With more, or less than 14 men, the Exercise will be the same as above, except that the proper handspikemen will take the duties of 9 and 10, the assistant handspikemen, those of 11 and 2, and the rear-men, those of 13 and 14.

The Captain of the gun is responsible that all stores and necessary gear are at the gun, and that throughout the Exercise all the Nos. perform their duties correctly.

Note.—Handspikemen, with 5, 6, or 7 men, 5 and 6; with 8, 9, 10, or 11
with 10 and 11 men, 9 and 2, and with all Nos. above 11, 11 and 2, except with
No. 2 attends train-tackle when the right rear-man is handspikeman. A Sta-
man to every

Stations for Casting Loose a Main Deck

Note.—No. 1 places handspikes, 3 and 4 bear out, and 1 and 2 trice up the
tackle, 3 and 4 clear away, and unhook train-tackle, and provide stores, 5 and 6
is in; when the side-tackles are clear, and train-tackle to the rear, 1 gives the
lower half-port; he then sees the bed properly secured and places coin at P. B.,
assist 2. With 5 men, 1 will hook on train-tackle. If the

"Words of Command."—"Prime," "Point," "Elevate," "Ready,"

EXERCISE.

for the Gun at which they are quartered.

Nos.	Exercise with 9 Men to an Upper Deck Gun.
1	The Captain; commands, attends the breeching, primes, points, fires, and stops the vent.
2	The 2nd Captain; assists 1, attends the apron, elevating screw, lock, and train tackle.
3	Loads, rams home, runs out, and trains.
4	Worms, sponges, rams home, runs out, and trains.
5	Gives shot and wad to 3, runs out, trains, and spans the breeching.
6	Gives sponge, rammer, and worm to 4, runs out, trains, and spans the breeching.
7 & 8	Run out, and attend handspikes.
9	Runs out, trains, and brings up shell.

Note.—With guns mounted on Rear chock carriages having side levers for running out, Nos. 7 and 8 will shift the side-tackles, and the left rear-man will attend roller handspike when necessary. With guns mounted on Hardy's carriages, the Exercise will be the same as above, except that No. 4 will attend compressor when the gun is *out*, and No. 8 when the gun is *in*.

men, 7 and 8; and with all Nos. above 11, 9 and 10. Assistant Handspikemen
68-prs. and 10-inch guns, when Assistant Handspikemen will be 11 and 12.
tionary Powderman is allotted to every gun on one side, and an extra powder-
two guns.

Gun with 6 men. (*Both sides manned.*)

half-port; when the port is up, 1 provides stores, 2 casts off, and hooks on train-
clear away and shift side-tackles, untoggle breeching, and span it when the gun
word "Elevate," and withdraws the coin to allow 3 and 4 to put down the
the gun is then run in, searched, loaded, and run out. With 7 men, 7 will
upper half-ports are made to take off, 3 and 4 will take them off.

"Fire," "Stop the Vent," "Sponge," "Load," "Run out."

ORDERS FOR MANUAL EXERCISE.

On coming to the gun, Nos. 1 see the locks fixed and fit for use, vents clear, sights adjusted to the distance named, and the guns searched, loaded, and run out without further orders.

WORDS OF COMMAND.

“ Prime.”
“ Point.”
“ Elevate.”
“ Ready.”
“ Fire.”
“ Stop the vent.”
“ Sponge.
“ Load.”
“ Run out,”

REMARKS ON THE DIFFERENT FIRINGS.

INDEPENDENT FIRING.

By this is meant, firing the guns independently of each other, each captain of a gun seizing the most favourable opportunity. This firing should always be used in action (unless ordered to the contrary) whenever the object is visible, the smoke from one gun not greatly impeding the firing of another.

(See Detail for Independent firing.)

FIRING IN SUCCESSION,

By this is meant, firing one gun after another in regular order, commencing from the foremost, or after gun, according as the wind is blowing from *aft*, or *forward*. This firing may be used with advantage, whenever a *continuous steady fire* is desired, as the smoke from one gun will not impede the firing of the next.

QUICK FIRING.

By this is meant, rapid independent firing, the tangent sight not being raised. This firing should be used when close alongside an enemy, as then but little pointing would be required,

(See Detail for Quick firing.)

BROADSIDE, AND DIVISIONAL FIRING.

By this is meant, firing the whole broadside, or a division of guns simultaneously, by order. Broadside firing should be used when the smoke hangs about the ship for some time, and divisional firing when the smoke clears away at shorter intervals, as then the fire would be more continuous. Broadside, or divisional firing could also be used with greater advantage within a moderate distance against stone forts than independent firing, from the increased concussion caused by a number of shot striking at the same moment. In divisional firing each deck, or the half of each deck, should be considered as a division according to circumstances.

CONCENTRATED FIRING.

By this is meant, firing guns previously laid by the aid of lines, or battens, so that the shot may cross each other at a given distance. This firing would be most effective in case of smoke, or darkness, the object being visible from the upper deck, or mast head, and may be used at distances within, and beyond the point of concentration, but the latter must never exceed double that, at which the shot cross.

IN INDEPENDENT FIRING,

No. 1 raises the tangent sight according to the charge and distance named, lays the gun for the object, and gives the word "Ready" as soon as the elevation is correct, keeping the direction on with the handspikes, and taking care not to fire till the side-tackle falls are clear.

IN QUICK FIRING,

No. 1 sees the gun laid horizontal, and run out for the object, primes as the gun goes out, taking care not to cock the lock till the muzzle is clear of the port-sill, and not to fire till the side-tackle falls are out of hand.

The only words of command to be given are, "Run in," "Run out," and "Ready." 2 chalks the bed, and coin, and the guns are relaid whilst loading.

ARRANGEMENT FOR FIGHTING BOTH SIDES.

When necessary to fight both sides, the whole of the guns are to be manned, and worked with "Half crews" (as in casting loose); but if from casualties or other causes this is not practicable, the right guns should be left *in* after the first round, and the left guns manned and worked with whole crews.

NOTE.—In Action, or Exercise, the working with "half crews" should not be continued beyond 3 or 4 rounds, as after this, owing to casualties and the fatigue of working on this plan, the firing would be more efficiently kept up by working every other gun.

INSTRUCTIONS FOR A SIMULTANEOUS CONCENTRATED FIRE.

"The lines should always be hooked on at the ports directly after casting loose."

The bearing, heel, and distance, having been given from the upper deck, the officers of the different divisions of guns will name the elevation, or depression to be given by marked coin (allowing for the distance and heel), together with the bearing, and then give the order "Lay the guns;" on which the Nos. 1 are to give the orders for training, holding the lines *immediately under* the marks overhead, denoting the bearing, and the guns are to be trained till the sights are *parallel* to the lines: Nos. 1 then give the word "Elevate" and direct 2 to give the guns the required elevation, or depression, making the lines fast to hooks overhead; they then resume the trigger lines, and wait steadily for the orders "Ready," "Fire," which are to be given by the officer attending the director.

DISMOUNTING, AND MOUNTING.

DISMOUNT THE GUN.

No. 1 gives the word "Run in," then "Elevate," takes out the coin, throws back depression chock, and sees the gun laid square between the housing-bolts; 2 prepares the train-tackle, hooks it to the runner, and lowers the gun; 3 and 4 pass the muzzle-lashing; 7 and 8 take out the keys, throw back the cap-squares, unhook the side-tackles, and see the carriage clear; rear-men provide and hook the runner.

When the muzzle-lashing is passed, 1 gives the word "Dismount," and all the Nos. man the train-tackle, except 1, 3, 4, and the handspikemen; 3 and 4 remain at the muzzle-lashing until all parts bear an equal strain; handspikemen assist until of no further use, and then go to the train-tackle.

MOUNT THE GUN. Everything will be replaced by the same Nos.

NOTE.—When ordered to "*Dismount*," No. 1 makes up the trigger-line round the lock, attends the coin to assist the handspikemen, leaves it on the bed ready for mounting, and when the gun is high enough, gives the order, "Well! Run the carriage back," he then replaces the depression chock.

REVOLVING GUN EXERCISE,

WITH A CREW OF 17 MEN, AND UPWARDS.

The crew are assembled as in the established gun exercise.
Gun Nos. 1, 2, 3, 4, 5, 6.
Auxiliaries, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, &c.
Traversing-tackle-men, 7, 8.
Handspikemen, 9, 10.
Assistant handspikemen, 11, 12.
Compressor-men, 13, 14.
Rear-men.—16, the right rear-man; 17, the left rear-man (*or the two highest Nos.*).

1. The Captain.
4. Sponger.
3. Loader
6. Assistant Sponger.
5. Assistant Loader.
2. Second Captain.

PROVIDING STORES.

No. 1. Provides 3 vent-plugs, priming wire, tube-box, spare trigger-line, vent-bit, sees the lock fixed and fit for use, and places handspikes.

2. Assists 1.

3. Shot-grummet, spare breeching, wet swabs, wads, and fuze-wrench.

4. Shot-grummet, spare breeching, fire-bucket, and two stop handspikes.

5. Bearer, and shot.

6. Sponge, rammer, worm, and shot.

Stationary and extra powdermen, two cartridge-cases, and two cartridges each.

NOTE.—Spare locks, and hammers are to be provided by the 2nd captain; axletrees, and trucks by 11 and 12.

Shells are always to be provided by the two highest Nos.

When pivot guns are mounted as broadside guns, and only *one* crew can be allotted to *two* guns, the "Stores" should be provided with "Both sides manned," as laid down in First Instruction.

EXERCISE WITH 17 MEN.

No. 1. The captain; commands, attends the breeching, primes, points, fires, and stops the vent.

2. The 2nd captain; assists 1, runs out, attends the apron, coin, lock, and rear-bolt.

3. Loads, rams home, runs out, attends fighting-bolt, shackles, and unshackles breeching.

4. Worms, sponges, rams home, runs out, attends stop-handspike, shackles, and unshackles breeching.

5. Brings up shot, or shell, runs out, traverses, and spans the breeching.

6. Gives sponge, rammer, and worm to 4, runs out, traverses, and spans the breeching.

7 and 8. Run out, attend traversing-tackles, and shift side-tackles.

9, 10, 11, and 12. Run out, and attend handspikes.

13 and 14. Run out, traverse, and attend compressors.

15. Runs out, and traverses.

16. Traverses, shifts traversing-tackle, attends stop-handspike and train-tackle.

17. Traverses, shifts traversing-tackle, brings up shot, or shell, and attends train-tackle.

NOTE.—These Nos. will be reduced for lighter, or increased for heavier guns, as may be necessary, when the rearmen will do the duties of 16 and 17. With less than 15 men, Nos. 11 and 12 will attend compressors.

When slide guns are fitted with Ferguson's Compressor, No. 8 is to attend it.

Stations for Casting Loose a Revolving Gun.

1 and 2 place handspikes, and provide stores; 3, 4, 5, and 6, provide stores, and clear away side-tackles; 7, 8, 16, and 17, clear away, and hook on traversing-tackles to fore part of slide; 9, 10, 11, and 12, clear away spans, and unscrew span shackle-bolts; 13, 14, 15, 16, and 17, clear away the ports and berthing. When the gun is clear, No. 1 gives the word "Action on the fighting-bolt * * *" "Right (or Left); Traverse," and when on the fighting-bolt *named*, "Well," the gun is then searched, loaded, and run out. While the gun is being searched, the breeching should be shackled to the ship's side.

Stations for Casting loose a Broadside pivot Gun (both sides manned).

No. 1 places handspikes, and provides stores; 3 and 4 provide stores, and clear away side-tackles; 5 and 6 clear away spans, and unscrew span shackle-bolts; 2, 7, 8, and 9, clear away, and hook on traversing-tackles, and unship ports, and berthing. When the gun is clear, No. 1 gives the necessary orders for getting it on the fighting-bolt; the gun is then searched, loaded, and run out. While the gun is being searched, the breeching should be shackled to the ship's side.

Words of Command.

	"Traverse."	
"Prime."	"Ready."	"Sponge."
"Point."	"Fire."	"Load."
"Elevate."	"Stop the vent."	"Run out."

Note.—When the direction of the gun is to be altered, the word "Traverse" is to be given if the gun is *in*, and "Point" when the gun is *out*.

The Service Charges for the following Guns.

Nature of Gun.	Weight.	Length.	Charge.		
			Distant.	Full.	Reduced.
	cwt.	ft. in.	lb.	lb.	lb.
68-Pounder . . .	95	10 0	16	12	8
10-Inch	84	9 4	12	..	..
8 "	65	9 0	10	8	5
8 "	60	8 10			
8 "	52	8 0	..	8	5
8-Inch Carronade.	36	5 4	..	5	..
32-Pounder . . .	56 & 58	9 6	10	8	6
32 " A . .	50	9 0	..	8	5
32 " B . .	45	8 6	..	7	5
32 " C . .	42	8 0	..	6	4
32 " . . .	32	6 6	..	5	3
32 " . . .	25	6 0	..	4	2½
32-Pounder Carron.	17	4 0	..	2lb. 10oz.	..
(The charge of all other Carronades is also 1-12th the weight of their shot.)					
24-Pr. Howitzer .	12½	4 8	2½	..	..
12 " . . .	10	4 6	2	..	..
12 " . . .	6½	3 9	1¼	..	..

The 68-pr., and 32-pr. guns of 58 and 56 cwt. may be double-shotted as far as . . . . 400 yards.
The "A" and "B" ditto ditto . . . . . . 400 "
The "C" guns ditto ditto . . . . . . 300 "
The 32 and 25 cwt. 32-pr. guns, and 8-inch 65 and 60 cwt. guns . 200 "

Carronades, the 8-inch 52 cwt. and the 10-inch guns, are never to be double-shotted.

Allowance for the Deflection of Shot occasioned by the Wind from a 32-pounder, 56 cwt., charge 8 lb.

In firing with a moderate breeze (force 4) *across* the range, an allowance of 1 foot for every 100 yards of distance has been found a correct guide.

With a moderate gale (force 7) *across* the range, 2 feet for every 100 yards of distance. At 1000 yards' distance with the latter force of wind (7) *against* the range, $\frac{1}{4}^{\circ}$ more elevation should be given; and when *with* the range, $\frac{1}{8}^{\circ}$ less elevation, than in the Range Tables.

MORTAR EXERCISE.

13-INCH SEA-SERVICE MORTAR.

PROVIDING STORES.

No. 1. Provides tube box, and plummet.
,, 2. Sponge, sheepskin, and handspike.
,, 3. Shell hooks, and handspike.
,, 4. Traversing tackles, and priming wire.
,, 5. Trigger-line, and fuze implements.
,, 6. Cartridge case.

EXERCISE WITH 8 MEN
(*in a Mortar Boat*).

No. 1. Commands, points, and primes.
,, 2. Sponges, wipes the bottom of the shell, uncaps the fuze, assists to put in shell, and traverses.
,, 3. Puts in cartridge, assists to put in shell, and traverses.
,, 4. Clears and serves the vent, pricks the cartridge, and traverses.
,, 5. Prepares fuzes, takes them to 8, traverses, and fires.
,, 6. Brings cartridge, and occasionally relieves 7.
,, 7. Prepares cartridges in the magazine,
,, 8. Prepares and hooks on shell in the hatchway.

Weight of mortar, 100 cwt. Extreme charge, 20 lb.
Weight of shell, 200 lb. Bursting charge, 10¼ lb.

N.B.—Land service mortars are worked in a similar manner, the only difference being that handspikes are required for running up and training, and a shell beam, or shell hooks for bringing up the shell. They are trained for the object by bringing them on with pickets placed in the parapet for the purpose.

All mortars with the ordinary coin, are elevated at an angle of 45°; this elevation may be altered if necessary by putting in an additional coin, or, by substituting a smaller one for that commonly used.

Weight of 13-inch land service mortar, 36 cwt. Extreme charge, 9 lb.
,, 10 ,, ,, 18 , ,, 4 ,,
,, 8 ,, ,, 8¼ ,, ,, 2 ,,

INSTRUCTIONS FOR THE USE OF RED HOT SHOT.

1. Red hot shot are not, for the present, to be fired from any guns but 68, and 32-pounders; the charges used must not exceed $\frac{4}{5}$ of the heaviest charge allowed for the gun, as the expansion of the shot by being heated considerably decreases the windage, and consequently much increases the stress on the gun: thus the 56 cwt. 32-pounder gun, whose heaviest charge is 10 lb., should not be fired with a higher charge than 8 lb.: the charges for other guns must be likewise proportionably decreased.

2. To prevent accidents, every ship will be allowed a red hot shot gauge, through which the shot are to be passed before they are brought away from the furnaces: a red hot shot bearer will also be supplied, in which the shot are to be triced up, and then conveyed to the guns; but if these are not issued, the shot can be triced up in the ash buckets.

3. Shot can be readily made red hot in the furnaces of steam vessels, and to a moderate extent this can also be done in the copper holes of sailing ships; a 32-pounder shot will become red hot in the furnace of a steamer in about 15 minutes, and care must be taken that they are not heated *beyond a bright red,* as otherwise they are liable to fuze, and to become misshapen, and if so used they would be very liable to jam in the gun.

4. It is very dangerous to fire a shot when jammed in a gun, but a red hot shot may be rapidly cooled by water, which will cause it to contract, and the shot will then probably be easily removed from the gun; but if not, a small quantity of powder introduced down the vent, after the charge has been destroyed, will effect its removal with certainty.

5. Shot expand about $\frac{1}{85}$ part of their diameter when heated to a bright red; therefore, as the mean diameter of 32-pounder shot, when so heated, is 6·273 inches, it is considered unsafe to fire red hot shot from either the 32 cwt. or the 25 cwt. 32-pounder guns, or from the 32-pounder carronade, as the windage of those guns is very small.

6. Clean shot, and shot that pass readily through the cold shot gauges, should be used for firing when red hot; the shot must be scraped and cleaned to remove the scales and dirt, and then passed through the hot shot gauges, before they are sent up from below.

7. Whilst shot are being heated they should be turned, as the part resting on the furnace bars heats much more rapidly than the upper part; when the shot are heated to a *bright* red they must be removed from the furnaces whether they are wanted, or not.

8. Great care must be taken that the cartridges used are not in any way broken, or damaged. A number of dry, and wet junk wads must be in readiness at the guns, also a number of wet grummet wads; these wads should be soaked in water for two or three hours beforehand, and then the water well pressed out of them, and care must be

taken that they are made small enough to fit easily in the guns when swelled by being soaked, otherwise the loading will be very difficult; the sponge should also be well damped, and water kept at the guns in case of accidents.

9. It has been found by experiment, that red hot shot do not burn more than the outer yarns of a well-soaked junk wad, even though left in the gun for a considerable period; and it has been also proved, that there is but little danger of the cartridge becoming ignited, even though quantities of smoke should come up through the vent; the grummet wad over the shot is necessary to prevent it from shifting in the bore from the motion of the vessel, or otherwise, and it should be well soaked to prevent it catching fire.

Precautions for loading guns with Red hot Shot.

First, the cartridge, then a dry junk wad, and then a wet junk wad are to be entered by No. 3, and 4 is to force them home together; it is recommended that this should be done with a damp sponge to insure any grains of powder being destroyed that may remain in the gun; No. 1 pricks the cartridge, and 4 withdraws and returns the sponge.

The shot is then to be brought up to the left of the gun, and entered by 3 and 4; the gun should be laid with sufficient elevation to allow the shot to roll home of itself; 3 then places a wet grummet wad over the shot, and 4 receives the rammer, forces it home, and assisted by 3, gives it two smart blows to insure the shot being close home.

After the loading is completed, the gun is to be run out, trained and elevated for the object in precisely the same manner as when firing cold shot; but the sooner the gun is fired the better, as the shot not only cools very rapidly when in the gun, but it is believed that i has a tendency to become misshapen from cooling unequally. It is further recommended, when firing red hot shot, to select those guns that may be the nearest to the engine room hatchway, and not to fire them indiscriminately from all guns.

A TABLE showing the angles subtended by the Mainmasts of French ships of war, between the Water-line, and the Truck, with the corresponding distances.

(Taken from Sir H. Douglas's Naval Gunnery.)

The observer is supposed to be 20 feet above the level of the water.

Yards.	Line of Battle Ships.			Frigates.		Cor-vettes.	Brigs.	Yards.
	120 Guns.	90 Guns.	82 Guns.	60 Guns.	44 Guns.	24 Guns.	18 Guns.	
	Truck to the Water Line, 220 feet.	Truck to the Water Line, 202 feet.	Truck to the Water Line, 192 feet.	Truck to the Water Line, 188 feet.	Truck to the Water Line, 168 feet.	Truck to the Water Line, 120 feet.	Truck to the Water Line, 112 feet.	
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	
200	20 20	18 47	17 54	17 33	15 46	11 22	10 37	200
300	13 48	12 42	12 6	11 51	10 37	7 37	7 7	300
400	10 25	9 35	9 7	8 55	7 59	5 43	5 20	400
500	8 21	7 41	7 18	7 9	6 24	4 34	4 16	500
600	6 59	6 25	6 6	5 58	5 20	3 49	3 34	600
700	5 59	5 30	5 14	5 7	4 35	3 16	3 3	700
800	5 14	4 49	4 35	4 29	4 0	2 52	2 40	800
900	4 40	4 17	4 4	3 59	3 34	2 33	2 22	900
1000	4 10	3 51	3 40	3 35	3 12	2 17	2 8	1000
1100	3 49	3 30	3 20	3 16	2 55	2 5	1 57	1100
1200	3 30	3 13	3 3	2 59	2 40	1 54	1 47	1200
1300	3 14	2 58	2 49	2 46	2 28	1 46	1 39	1300
1400	3 0	2 45	2 37	2 34	2 17	1 38	1 31	1400
1500	2 48	2 34	2 26	2 23	2 8	1 32	1 25	1500
1600	2 37	2 24	2 17	2 14	2 0	1 26	1 20	1600
1700	2 28	2 16	2 9	2 7	1 53	1 21	1 15	1700
1800	2 20	2 8	2 2	2 0	1 47	1 16	1 11	1800
1900	2 13	2 2	1 56	1 53	1 41	1 12	1 7	1900
2000	2 6	1 56	1 50	1 48	1 36	1 9	1 4	2000
2200	1 55	1 45	1 40	1 38	1 27	1 2	0 58	2200
2400	1 45	1 36	1 31	1 30	1 20	0 57	0 53	2400
2600	1 37	1 29	1 24	1 23	1 14	0 53	0 49	2600
2800	1 30	1 23	1 19	1 17	1 9	0 49	0 46	2800
3000	1 24	1 17	1 13	1 12	1 4	0 46	0 43	3000
3200	1 19	1 12	1 8	1 7	1 0	0 43	0 40	3200
3400	1 14	1 8	1 5	1 3	0 57	0 40	0 38	3400
3600	1 10	1 4	1 1	1 0	0 53	0 38	0 35	3600
3800	1 6	1 1	0 58	0 57	0 51	0 36	0 34	3800
4000	1 3	0 58	0 55	0 54	0 48	0 34	0 32	4000

A TABLE showing the angles subtended by the Mainmasts of French ships of war, between the Water-line, and the Topmast crosstrees, with the corresponding distances.

(Taken from Sir H. Douglas's Naval Gunnery.)

The observer is supposed to be 20 feet above the level of the water.

Yards.	Line of Battle Ships.			Frigates.		Corvettes.	Brigs.	Yards.
	120 Guns.	90 Guns.	82 Guns.	60 Guns.	44 Guns.	24 Guns.	18 Guns.	
	Topmast Cross-trees to the Water Line, 158 feet.	Topmast Cross-trees to the Water Line, 151 feet.	Topmast Cross-trees to the Water-Line, 138 feet.	Topmast Cross-trees to the Water Line, 139 feet.	Topmast Cross-trees to the Water Line, 121 feet.	Topmast Cross-trees to the Water Line, 85 feet.	Topmast Cross-trees to the Water Line, 77 feet.	
	° '	° '	° '	° '	° '	° '	° '	
200	14 52	14 13	13 2	13 7	11 28	8 5	7 20	200
300	9 59	9 33	8 45	8 48	7 41	5 24	4 54	300
400	7 31	7 11	6 34	6 37	5 46	4 3	3 40	400
500	6 1	5 45	5 16	5 18	4 37	3 14	2 56	500
600	5 1	4 48	4 23	4 25	3 51	2 42	2 27	600
700	4 18	4 7	3 46	3 47	3 18	2 19	2 6	700
800	3 46	3 36	3 18	3 19	2 53	2 2	1 50	800
900	3 21	3 12	2 56	2 57	2 34	1 48	1 38	900
1000	3 1	2 53	2 38	2 39	2 19	1 37	1 28	1000
1100	2 45	2 37	2 24	2 25	2 6	1 29	1 20	1100
1200	2 31	2 24	2 12	2 13	1 55	1 21	1 13	1200
1300	2 19	2 13	2 2	2 2	1 47	1 15	1 8	1300
1400	2 9	2 3	1 53	1 54	1 39	1 9	1 3	1400
1500	2 0	1 55	1 45	1 46	1 32	1 5	0 59	1500
1600	1 53	1 48	1 39	1 39	1 26	1 1	0 55	1600
1700	1 46	1 42	1 33	1 34	1 21	0 57	0 52	1700
1800	1 40	1 36	1 28	1 28	1 17	0 54	0 49	1800
1900	1 35	1 31	1 23	1 24	1 13	0 51	0 46	1900
2000	1 30	1 26	1 19	1 20	1 9	0 49	0 44	2000
2200	1 22	1 19	1 12	1 12	1 3	0 44	0 40	2200
2400	1 15	1 12	1 6	1 6	0 58	0 40	0 37	2400
2600	1 9	1 6	1 1	1 1	0 53	0 37	0 34	2600
2800	1 5	1 2	0 56	0 57	0 50	0 35	0 31	2800
3000	1 0	0 57	0 52	0 53	0 46	0 32	0 29	3000
3200	0 56	0 54	0 49	0 49	0 43	0 30	0 27	3200
3400	0 53	0 51	0 46	0 47	0 40	0 29	0 26	3400
3600	0 50	0 48	0 44	0 44	0 38	0 27	0 24	3600
3800	0 47	0 45	0 41	0 42	0 36	0 25	0 23	3800
4000	0 45	0 43	0 39	0 40	0 35	0 24	0 22	4000

INSTRUCTIONS FOR ADJUSTING THE WOODEN SIDE TANGENT SCALES TO GUNS, AND FOR THEIR USE.

The gun, when on its carriage, and run out in its place in the ship, is to be laid perfectly horizontal, and the foot of the scale is then to be shortened (if necessary), so that, when held, and resting in a perpendicular position on the step of the bracket, the line of the Zero, or O, is brought into coincidence with the line of the quarter sight.

Previous to using the tangent scale, it will be necessary to observe the degree of the heel, or inclination of the ship, by means of the pendulum supplied with the scales, and an elevation, or depression is to be given to the gun to the amount shown, in order to bring it to the horizontal position; and the degree of elevation, required for the estimated distance from the object to be fired at, is to be reckoned from the point on the scale then opposite to the quarter sight.*

NOTE.—The gun is to be laid horizontally by means of the spirit level, or by common level with plumb line, laid from back to front sight.

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* *Vide* Tangent scales, pages 52, 53, of "Artillerist's Manual, etc."

RANGES WITH SEA-SERVICE IRON ORDNANCE, OBTAINED ON BOARD HER MAJESTY'S SHIP "EXCELLENT."

Elevation by Tangent-sight.

Nature of Gun.	Length.	Weight.	Diameter of Bore.	Windage.	Weight of Shot, or Shell.	Charge.	The Elevation, and Range in Yards, with corresponding Times of Flight.																	
							¼	½	¾	1	1½	2	2½	3	4	5	6	7	8	9	10	11	12	13	14
	ft. in.	cwt.	in.	in.	lb.	lb.																			
10-In.	9 4	86	10·	·16	Shot Shell 84	12	140	260 ¾"	380	500 1½"	650 2¼"	800 3"	950 3½"	1100 4"	1400 4¾"	1600 5¾"	1780 6¾"	1940 7½"	2100 8¼"	2240 9"	2380 9¾"	2520 10¾"	2660 11½"	2800 12¼"	2930 13"
8-In.	9 0 8 10	65 60	8·05	·125	Shot 56	10	160	300	430	550	750	900	1050	1200	1500	1760	1980	2160	2340	2520	2700	2850	3000	3120	3240
,,	,,	,,	,,	,,	Shell 51	10	200	350 1"	480 1½"	600 2"	800 2½"	950 3"	1100 3½"	1240 4½"	1500 5¼"	1760 6¼"	1980 7¼"	2160 8¼"	2340 9¼"	2500 10"	2660 10¾"	2780 11½"	2900 12¼"	3000 13"	3100 13½"
8-In.	9 0 8 10 8 0	65 60 54	8·05	·125	Shot 56	8	140	260	380	500	680	830	980	1130	1430	1660	1880	2060	2240	2420	2600	2760	2900		
,,	,,	,,	,,	,,	Shell 51	8	150	300 1"	430 1½"	550 2"	730 2½"	880 3"	1020 3½"	1160 4"	1430 5"	1660 6"	1880 7"	2060 8"	2240 9"	2400 9¾"	2560 10½"	2680 11¼"	2780 12"		
68-Pr.	10 0	95	8·12	·198	Shot 68	16	220	340 ½"	500 1"	640 1½"	860 2¼"	1060 3"	1240 3⅝"	1400 4¼"	1700 5¼"	1960 6¼"	2180 7¼"	2380 8¼"	2560 9¼"	2720 10¼"	2880 11⅛"	3040 12"	3200 12⅞"	3340 13¾"	3480 14⅝"
,,	,,	,,	,,	,,	Shot 68	12	200	300	400	510	730	940	1160	1330	1590	1830	2060	2270	2470	2640	2790	2940	3070	3200	3330
,,	,,	,,	,,	,,	Shell 51	12	400 1"	510 1½"	620 1¾"	730 2"	930 2¾"	1090 3¼"	1230 3¾"	1340 4"	1560 5"	1770 6"	1970 7"	2170 8"	2360 9"	2530 10"	2690 11"	2850 12"	2990 13"	3130 14"	3260 15"
32-Pr.	9 6	58	6·375	·198	Shot 32	10	320	460	600	720	930	1140	1320	1500	1740	1980	2200	2380	2560	2720	2880	3020			
,,	,,	,,	,,	,,	Shell 24	10	440 1⅜"	600 1½"	710 1¾"	820 2"	1000 2¾"	1140 3⅜"	1280 3¾"	1400 4¼"	1630 5½"	1840 6½"	2030 7½"	2200 8¼"	2360 9"	2500 9¾"	2640 10¾"	2770 12"	2880 14"		

NOTE.—It is better, as a rule, not to fire 6-inch Shells with a higher charge than 8 lb., as, when fired with 10 lb. charges, they sometimes burst prematurely. In firing Spherical Case from heavy guns, the Charges, Elevations, and Times of Flight may be taken as for Common Shell.

RANGES WITH SEA-SERVICE IRON ORDNANCE, OBTAINED ON BOARD HER MAJESTY'S SHIP "EXCELLENT."

Elevation by Tangent-sight.

Nature of Gun.	Length.	Weight.	Diameter of Bore.	Windage.	Weight of Shot, or Shell.	Charge.	The Elevation, and Range in Yards, with corresponding Times of Flight.																		
							¼	½	¾	1	1½	2	2½	3	4	5	6	7	8	9	10	11	12	13	14
	ft. in.	cwt.	in.	in.	lb.	lb.																			
32-Pr.	9 6	56	6·41	·233	Shot 32	10	300	440	570	700	900	1100	1280	1460	1700	1900	2100	2280	2460	2620	2780	2920	3060	3180	3300
,,	,,	,,	,,	,,	Shell 24	10	430 1⅛"	570 1¼"	700 1¾"	800 2"	960 2½"	1100 3"	1230 3½"	1350 4"	1570 5"	1760 6"	1940 7"	2100 7¾"	2250 8½"	2400 9¼"	2530 10"	2660 11"	2780 12"	2880 13"	2970 14"
,,	,,	,,	,,	,,	Shot 32	8	250	380	500	600	800	1000	1200	1380	1620	1820	2020	2200	2340	2480	2620	2760	2900		
,,	,,	,,	,,	,,	Shell 24	8	350 1"	500 1¼"	620 1¾"	720 2"	880 2¼"	1040 3"	1180 3¼"	1320 4"	1520 5"	1720 6"	1920 7"	2080 7¾"	2220 8¼"	2360 9¼"	2500 10"	2620 11"	2740 12"	2840 13"	2940 14"
32-Pr.(A)	9 0	50	6·375	·198	Shot 32	8	300	440	580	700	900	1100	1280	1460	1680	1900	2100	2280	2460	2620	2780				
,,	,,	,,	,,	,,	Shell 24	8	380 1"	520 1¼"	640 1⅝"	740 1⅞"	910 2¼"	1070 3"	1220 3¼"	1340 4¼"	1580 5¼"	1790 6½"	1970 7¼"	2140 8¼"	2310 9"	2470 10"	2620 11¼"				
32-Pr.(B)	8 6	45	6·35	·173	Shot 32	7	260	400	520	640	840	1020	1200	1380	1600	1820	2020	2200	2360	2520	2680				
,,	,,	,,	,,	,,	Shell 24	7	300 ¾"	460 1⅛"	600 1½"	700 1¾"	860 2⅛"	1020 2¾"	1180 3¾"	1300 4¼"	1500 5¼"	1700 6¼"									
32 Pr.(C)	8 0	42	6·35	·173	Shot 32	6	240	360	480	600	800	960	1120	1280	1500	1700	1880	2060	2240	2420	2580				
,,	,,	,,	,,	,,	Shell 24	6	200	360 1⅛"	500 1½"	600 1¾"	800 2¼"	960 2¾"	1120 3½"	1240 4¼"	1460 5¼"	1660 6¼"									

NOTE.—It is better, as a rule, not to fire 6-inch Shells with a higher charge than 8 lb., as, when fired with 10 lb. charges, they sometimes burst prematurely. In firing Spherical Case from heavy guns, the Charges, Elevations, and Times of Flight may be taken as for Common Shell.

RANGES WITH BRASS ORDNANCE. Elevation by Tangent-sight.

Nature of Gun.	Diameter of Bore.	Windage.	Weight of Shot, or Spherical Case.	Charge.	Elevation, and Range in Yards, with corresponding Lengths of Fuze.												
					¼°	½°	¾°	1°	1½°	2°	2½°	3°	3½°	4°	4½°	5°	6°
Howitzer. 24-Pr. 4 ft. 8 in. 12½ cwt.	in. 5·72	in. ·12	Sph. Case, 20 lb. No. of Balls, 100	lb. 2½ Burster, 3 oz.	250	300	350	400	500	600	700	800	900	1000	1100	1200	1350
					..	·1	·1	·15	·2	·25	·35	·45	·55	·65	·75	·85	1·0
					These Ranges may also be used for the Hollow Shot, and Shell.												
Howitzer. 12-Pr. 4 ft. 6 in. 10 cwt.	4·58	·12	Shot. 12 lb.	2 lb. Burster, 1 oz. 12 drs.	⅝°	⅞°	1⅛°	1½°	2°	2½°	3°	3½°	4°	4½°	5°	6°	7°
					200	300	400	500	650	800	950	1050	1150	1250	1350	1550	1700
					·1	·15	·2	·25	·35	·5	·6	7	·8	·9	1·0		
					These Ranges may also be used for the Spherical Case, and Common Shell												
Howitzer. 12-Pr. 3 ft. 9 in. 6½ cwt.	4·58	·12	Sph. Case, 10 lb. No. of Balls, 75	1¼ lb. Burster, 1 oz. 12 drs.	½°	¾°	1°	1½°	2°	2⅝°	3°	3⅜°	3¾°	4⅛°	4½°	5°	6°
					250	300	350	450	550	650	700	750	800	850	900	950	1050
					·1	·1	·15	·2	·3	·4	·45	·5	·6	·6	·65	·7	·8
					These Ranges may also be used for the Hollow Shot, and Shell.												
Gun. 6-Pr. 5 ft. 6 cwt.	3·67	·12	Sph. Case, 5 lb. No. of Balls, 30	1¼ lb. Burster, 12 drs.	¼°	½°	¾°	1°	1½°	2°	2½°	3°	3¾°	4½°	5¼°	6°	
					300	400	500	600	700	800	900	1000	1100	1200	1300	1400	
					·1	·15	·2	·25	·3	·4	·5	·6	·7	·8	·9	1·0	
					These Ranges may also be used for the Shot.												

NOTE.—In firing Spherical Case from heavy guns, the Charges, Elevations, and Times of Flight may be taken as for Common Shell.

PART XII.

BATTERIES, AND FORTIFICATION.

BATTERIES.

A BATTERY, in respect to its profile, may be either elevated, half sunken, or sunken; and it is usually reveted with gabions, fascines, sand bags, &c.

An elevated battery has its whole parapet raised above the natural surface of the ground, and, to procure the mass of earth required, a ditch is usually dug directly in front of the parapet.

A half-sunken battery has its interior space, or terreplein, sunk some inches below the natural surface, and its parapet is composed of the earth thus obtained, and of that taken from a narrow ditch in front.

A sunken battery has the whole of the earth taken from the interior space to form the parapet; and it must therefore be lowered from 2 feet to 3 feet 6 inches, according to the height of the gun carriages to be used.

The half-sunken battery is constructed the quickest, as the diggers can work both in front, and rear, at the same time. In a sunken battery, the diggers are as much crowded as in an elevated one, but, since the mass of parapet to be raised is smaller, it may be completed in much less time.

Casemates, or vaulted batteries, are made bomb-proof, and the embrazures are cut through the revetment.

Barbet batteries have no embrazures, the guns being placed on traversing platforms to enable them to fire over the parapet.

A direct fire from a battery is when the line of fire is perpendicular to the parapet, and an *oblique fire* when it is oblique. The direct fire being preferable, the battery should be placed parallel to the object against which the fire is to be directed.

The line of fire is an imaginary line drawn through the centre of an embrazure, in the direction of the object against which a battery is constructed.

Embrazures are openings cut through parapets, flanks of bastions, &c., for guns to fire through.

The neck of the embrazure is the inward, or narrowest part of it.

The mouth of the embrazure is the outward, or widest part of it.

The sole of the embrazure is the bottom, or space, between the cheeks, or sides.

The sill is the front of the sole.

The genouillere is that part of the parapet which is beneath the sill of the embrazures.

The merlon is the portion of the parapet contained between two embrazures.

The following dimensions are requisite to be proof,

Against musketry.—3 feet	. . . .	when of earth.
6 inches	. . . .	„ stone.
12 inches	. . . .	„ fir.
5 inches	. . . .	„ oak.
9 inches	. . . .	„ brick.

Against cannon.—4 feet, when of wood, or brick.			
6	feet against	6-pounders,	when of earth.
9	„	9-pounders,	ditto.
14	„	12-pounders,	ditto.
18	„	18 & 24-pounders,	ditto.

Note.—A 6-pounder shot, with a charge of one pound, will penetrate *a mass of ice* to the depth of 4½ feet, at the distance of twenty-one yards.

GENERAL DIMENSIONS OF AN ELEVATED GUN BATTERY,

reveted with fascines.

	ft.	in.
Space from the centre of one embrazure to that of the next, without traverses	18	0
Ditto, with traverses	22	0
Slope of the interior revetment, per foot (one-fourth its height)	-	3
Fall of the superior slope, ditto (one-twelfth ditto)	-	1
Interior width of embrazures, measured on the sill	2	0
Exterior ditto, measured on the sole, at 12 feet from the sill	7	0
Slope of the cheeks of embrazures at the neck, per foot (one-sixth of their height)	-	2
Ditto, at the mouth, per foot (one-fourth their height) . . .	-	3
Distance from the centre of an embrazure to the foot of the slope of an adjoining traverse	7	6
Distance from the centre of an embrazure to the foot of the slope of an adjoining epaulment	5	0
Height of the sill; gun, on a travelling carriage	3	6
„ „ standing carriage	2	4

DIRECTIONS FOR TRACING A BATTERY.

Batteries at sieges are generally traced in the dusk of the evening.

Detail of Men, and tools required:

Tracers.—1 *non-commissioned officer, and 2 privates.*

Tools.—1 *ground-square.* 1 *measuring tape.* 1 *white tracing-line.* 2 *ten-feet rods.* 1 *bundle of pickets.* 1 *mallet.*

Directions.—The tracing-pickets, and mallet, are carried in a sand-bag, and a few long pickets are necessary to mark the embrazures.

A line should be stretched about 40 feet in the direction of the object against which the battery is to be erected; this will show *the line of fire*. By means of a ground square, a line may be laid down at right angles to the former, touching the first placed picket. This will be the interior base line. Another line must be placed parallel to this, at a distance equal to the sum of the breadth of the base of the parapet, breadth of the berm (if any), and breadth of the slope of the ditch (viz., about 27 feet), which line will represent the reverse slope of the ditch. A picket is then driven in on the interior base line, where it is intended to have one extremity of the battery, and as many long pickets (18 feet apart), measuring from this end, as there are guns, which will mark the centre of the embrazures. Then one more picket, 18 feet distant from the last, will show the other extremity. For the embrazures, drive in a picket at the distance of one foot on each side of the centre of the embrazures, for the width of the neck. Set off, and drive in pickets 3 feet 6 inches on each side of, and perpendicular to the line of fire, for the width of the mouth.

WORKING PARTY; TOOLS; AND MATERIALS REQUIRED

for each gun; mortar; traverse; or epaulment; in an elevated fascine battery.

2 *sappers, with* 6 *assistants*, to revet the work.

12 *infantry*, to excavate the ditch, and form the parapet.

9 *pickaxes*, 15 *shovels, or spades*, 14 *fascines*, 18 *feet long*, 1 *bundle of* 50 *pickets to* 6 *fascines*, 3 *mauls*, 3 *rammers*, 1 *saw* to every two guns, 1 *hatchet* per gun, 1 *bill-hook*, 1 *field-service level*, 1 *six-feet rod*, 1 *bundle of matches* to every three guns, 1 *lantern*, do., 1 lb. *of candles*, do., 1 *bundle of gads* to each gun, 1 *tape of* 50 *feet in length* per battery.

A battery will seldom be completed in less than 24 hours, when executed by inexperienced workmen; but by those inured to hard labour, and with proper reliefs, in about 10 hours. In light soil, that can be easily dug without the aid of a pickaxe, a man can, in 8 hours, load from 19 to 20 cubic yards of earth on barrows. If a pickaxe be required, 2 men will do the same quantity of work. A man can wheel 20 cubic yards of earth per day to a distance of 30 yards on level ground, or 20 yards on a ramp. Twenty cubic yards of earth will fill 500 wheelbarrows. When near the surface, in soil requiring but little the use of the pickaxe, an excavation of 6 cubic yards in a day of 8 hours would be a fair task for a soldier, who in general is little accustomed to working with the pickaxe, and shovel.

SHELTER FROM AN ENEMY'S FIRE.*

The following method of sheltering the workmen from the enemy's fire was used with great success during the construction of the batteries. It was towards the end of the siege that Lieutenant

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* *Vide*—"United Service Magazine," No. CCCVIII.

Néandre received orders to construct a battery 130 paces from the counterscarp, the covered way being strongly occupied by the enemy. Foreseeing the difficulties that would occur, Lieutenant Néandre provided 120 common platform planks, and, when the gabions were in their places, arranged the planks outside them, in such a manner as to present an inclined plane, (one end of the plank being supported on the gabion, and the other end resting on the ground towards the enemy): the gabions were then half filled with earth, and the pickets driven in. At this moment the enemy threw some fire balls, and fired a few shot, all of which went over. Soon after, the workmen were assailed with a well-sustained fire of musketry; but, on the balls striking the epaulment, they ricochéd, and passed over the workmen, so that not a single man was hit. The battery was finished in a few hours, when the planks were drawn in, and used for the platforms.

A portable framework might be rapidly made, and used instead of the gabions, to obtain immediate cover from musketry fire; and, for sapping, the framework, with the planks fixed thereon, might be readily moved on trucks, as a substitute for the present sap roller.

EPAULMENTS.

Batteries at sieges are generally secured on one flank at least, by a parapet called an epaulment, forming an obtuse angle with that of the battery. Their use is to secure the reverse of the terreplein from any flanking fire, and they are not in general made so thick as the parapet, being seldom subject to a direct fire.

ELEVATED SAND-BAG BATTERIES.

The base of the interior slope of a battery reveted with sand-bags is rather broader than that of one reveted with fascines, being about one-third the height of the parapet. *Bushel sand-bags* are now the only kind in use, and *when filled are of the following dimensions:*

Length 20 *inches, breadth* 10 *inches, depth* 5 *inches.*

Number required per gun,—for the interior revetment	262
Ditto Ditto for the cheeks . . .	360
Total . . .	622

Sand-bags are laid *header*, and *stretcher*, as in masonry; the ends which are tied being always hid. As the sand-bags near the neck of the embrazure would be destroyed after a few hours' firing, and constantly require repairing, gabions, or casks should be substituted for them.

Howitzer batteries are similar to those for guns, except that the interior openings of the embrazures are 2 feet 6 inches, and the soles are raised, towards the front, about 10°, in order to cover the gunners as much as possible.

Mortar batteries are constructed with the same dimensions as gun batteries (the parapet being generally 8 feet high, and from 18 to 22 feet thick), but, as they have not embrazures, the ditch of elevated batteries is made two feet deeper to obtain the requisite quantity of earth. A preference would in general be given to the sunken, or half-sunken profile for a mortar battery, on account of its requiring less time for its construction, and it being of no consequence whether the platforms are sunken, or otherwise. Mortars are placed at the distance of 15 feet from centre to centre of each other, where no traverses intervene; and the parapet has the same profile as a gun, or howitzer battery.

When fired at	45°	they are placed	12	feet from the revetment.
Ditto	30°	ditto	13	ditto
Ditto	20°	ditto	21	ditto
Ditto	15°	ditto	30	ditto
Ditto	10°	ditto	40	ditto

HALF-SUNKEN BATTERIES.

The sill is about half its total height above the natural surface of the ground; the most convenient depth to which the terreplein may be sunk is 2 feet. The height of a sill for a travelling carriage will be 18 inches, and for a garrison carriage one foot above the natural level. The profile of the parapet is the same as in an elevated battery.

Number of sand-bags required for reveting one merlon .	180
Ditto ditto for cheeks of embrazures .	360
Total . . .	540

In forming the epaulment of a half-sunken battery, the earth is taken from a ditch in front, six feet wide, and about five feet deep.

SUNKEN GUN BATTERIES.

The soles of the embrazures are on a level with the natural ground, therefore the terreplein is sunk a sufficient depth for the solid, and the merlons are formed of the excavated earth. The height of the solid depends on the nature of gun carriage to be used. The first operation is to trace out the embrazures. The profile is the same as in the elevated battery. Should there be traverses, all the earth excavated from the interior will be required; if not, the overplus may be scattered in the rear.

RICOCHET BATTERIES.

Ricochet firing is the art of projecting shot, or shell, with a certain velocity, and in such a direction as to insure its striking the ground at any spot that may be required; afterwards making several grazes upon the earth, and destroying, or striking all that may oppose its progress. The piece of ordnance is loaded with a diminished charge of powder, and the elevation is from 3° to 10°, which causes the shot to bound or hop along the ground. The smaller the angle under which the shot is made to ricochet, the longer it will preserve its force, and have effect, as it will sink in the same proportion so much less into the ground on which it bounds. In the ricochet of a fortress, or field-work, the elevation should seldom exceed 10° to throw the shot over the crest of the parapet; but in the field, the objects to be fired at being principally infantry, and cavalry, the guns need seldom be elevated above 3°; as, under greater angles, the shot would be apt to bound too high, thereby defeating its intended purpose.

Ricochet batteries should, if possible, be at a distance of 400 yards, or not exceeding 600 yards; as, from the uncertainty of the fire at a greater distance, at least two-thirds of the ammunition might be expended without producing any good effect.

The best elevation to enfilade a work being from 6° to 9° measured above the parapet, the charge should be regulated accordingly, which varies from one half, to one tenth the service charge.

Ricochet firing is very efficacious in dismounting the guns on the faces, or flanks of bastions, &c., the batteries for this purpose being erected on the prolongation of these works, and as nearly as possible perpendicular thereto, by which their whole length will be exposed to the effects of plunging, and destructive ricochet fire.

Vide Tables of Ricochet practice, pages 75, 80, 81.

FASCINES.

Fascines are bundles of wood of various lengths, according to the purposes to which they are to be applied.

Fascines for a revetment should be strong, and well bound. When small brushwood is used, *they are made* 6 *feet long, and* 7 *inches in diameter*, and are firmly bound with four or five withes, or gads. *Sap faggots* are 3 feet long, and 9 inches in diameter.

The gads are made of rods 5 feet long, first twisted until the fibres separate, the smaller end is then turned round, so as to form a loop, or noose. To make a fascine 6 feet long, the workmen set up three fascine horses on the same level, and in a right line.

(*A fascine horse* is formed with two pickets, each 5 feet long, driven about 1 foot obliquely into the ground, so as to cross each other at right angles 2 feet above the surface of the earth; and they are fastened together at their point of meeting, with cord, three or four-thread spun yarn, or gads.) The brushwood, which should not exceed from 1½ to 2 inches in diameter at the butt end, stripped of all its leaves and smaller branches, and 5 or 6 feet long, is then laid on the fascine horses, the thick ends being placed alternately at each end. The large stuff must be used to form the exterior, and the smaller twigs the interior of the fascine. Before binding the fascine, it must be compressed with a *fascine chooker*, which consists of a cord, or chain, equal in length to one and a half times the circumference of the fascine, fastened at one end to a lever 5 feet long and 2½ inches in diameter, with a loop at the other end, into which, after passing the chain round the fascine near the part to be bound, a lever, similar to the one already described, is inserted, and the brushwood is squeezed tightly together until the gad is tied. The fascine must be compressed in a similar manner before each gad is fastened. *The weight of the fascine* is about 33 lb. *Three men can make a* 6 *feet fascine in twenty minutes.* Two of the workmen place the brushwood, while the third prepares the gads. If large brushwood can be procured, the fascines should be 18 feet long, the strength of the revetment being materially increased by diminishing the number of joints. *When the fascines are* 18 *feet long*, they are made 9 inches in diameter, and are bound with 13 gads, if the brushwood is good, but with 17 if it is bad, the fascine horses being one yard apart. *This fascine weighs* about 2 cwt. *Four men can make an* 18 *feet fascine in two hours*, or, if the wood be cut and brought to them, they can make four fascines in that time. *They require* 3 *bill-hooks*, 1 *saw*, 1 *fascine choaker* (*each lever about* 6 *feet long*), *and* 6 *fascine horses.* Three men prepare the brushwood, and lay it on the horses, while the fourth makes the gads.

The revetment is formed in proportion as the parapet is raised, the first fascine being half buried in the banquette, with three pickets driven vertically through it, each picket being from 3 to 4 feet long, and from 1¼ to 1½ inch in diameter at the thickest end. The second row of fascines is then laid a little in front of the first, so as to form the required slope, and three pickets are driven through each fascine; the extreme pickets through the fascine previously laid in the direction of the slope, the other perpendicular to the slope.

The joints of the different rows of fascines should be so broken, that no two adjoining joints may be in the same line, and the ends of the fascines at the angles should alternately be flush with, and be inserted in the parapet; care being taken to lay the fascines so that the ties of the gads may be concealed in the parapets. Six rows of large fascines are sufficient to form the revetment of a parapet, the upper row being covered with a layer of sods, the grass upwards. When fascines of seven inches in diameter are used, eight rows are required.

GABIONS.

Gabions are cylindrical baskets open at both ends, and are very commonly used to revet parapets. For the interior of parapets they should be 3 *feet in height, and diameter. The common gabions are* 2 *feet in diameter, and* 2 *feet* 9 *inches high, in the web.*

To make them.—A directing circle (11½ inch radius) consisting of two hoops, kept apart by bits of wood, to which both the hoops are secured with packthread, is first made. The diameter of the hoops must be such as to permit of the pickets for the gabion being driven between the exterior of the one, and the interior of the other. The directing circle is then laid on a level piece of ground, and from seven to twelve pickets are driven at equal distances apart, between the hoops; the number of pickets depending on the size of the rods, or brushwood with which the basket-work is to be made. The circle is then raised, and fastened to the middle of the pickets, and the web is made above it, two or three rods being used at the same time; the workman twisting them round each other while he interlaces them with the pickets, striking down the web from time to time with a stick. The *randing*, or *basket work*, is continued to near the top of the pickets, where it is secured with four gads, each one passed round one of the pickets and four or five of the rods, which should be from 8 to 10 feet long, and not more than half an inch in diameter. The gabion is then pulled up, the finished end is placed on the ground, and the directing circle being removed, the remainder of the web is completed and secured as before described.

Two men can make a gabion in three quarters of an hour, using about 80 rods for each gabion.

In forming the revetment, the gabions are placed touching each other with a slope of one quarter the height; the first row is surmounted with two rows of fascines side by side, and a second row of gabions rests on them.

SAP ROLLERS.

Exterior cylinder,	length,	6 feet,	diameter,	4 feet.	
Interior	,,	6 ,,	,,	2½ ,,	
Pickets	Exterior cylinder,	20	6 feet long, by 1 to 1½ inch diameter.		
	Interior ,,	14			

Rods, 1 inch thick.

Pickets for stuffing, 1½ inch diameter: average space between cylinders, 8 inches.

Time for making large cylinder, 9 hours; small cylinder, 6 hours; and 2 hours for stuffing.

SOD, OR TURF.

A revetment is sometimes made with sods of unequal sizes, called *headers*, and *stretchers*.

The headers are 1 *foot* 6 *inches long*, 1 *foot wide, and about* 4½ *inches thick.*

The stretchers are 1 *foot wide, and long, and about* 4½ *inches thick.*

Sometimes the sods are first cut all of the same dimensions—viz., 1½ foot long and 1 foot wide; this sod is then cut diagonally, across, so as to form two, and they are then all laid as headers. This saves nearly half the turf, and labour. The sods should be cut from good meadow land, previously mown, and watered; but the sods should not be laid or built when wet, because they would shrink in dry weather, and all the joints would open. The sod-work is laid with the grass downwards, either alternately headers, and stretchers, or two stretchers to one header; care being taken that the joints of no two rows fall immediately over one another, which is termed breaking joint. If the layers of sods are laid perpendicular to the slope, they will answer better than if laid horizontally. Each sod should have two or three pegs driven through it, to secure it to the work beneath. When the revetment is completed, the whole should be cut off smooth to the proper slope; a pair of hedge-clippers, or a cutting knife, will answer well for this purpose.

One man can lay 19 *square yards of sod-work in eight hours*, when the sods are brought to the spot, and require no previous trimming.

PLATFORMS.

To facilitate the working of a gun, it must be placed on a platform of stone, or timber, and plank: but, as a temporary measure, when required to fire only in one direction, timbers to take the wheels will suffice. The usual inclination given to platforms, from the rear to the front, is half an inch per foot. Platforms on barbettes should be perfectly level, and their dimensions must depend on the extent of the lateral range which may be required.

In laying a gun platform, the first thing to be done is to fix the *hurter*, which may be a piece of timber 7 or 8 feet long, and 7 inches square, or a strong fascine 9 feet in length may be advantageously used. The hurter is intended to take the wheels, or trucks of the carriage when the gun is run out, and to prevent their damaging the interior slope of the parapet. The position of the hurter necessarily depends therefore on the steepness of the interior slope. The hurter should be placed perpendicular to the axis, or central line of the embrazure. Three, four, or five sleepers of from 6 to 8 inches square, are then laid, their upper surface on a level with the bottom of the hurter, and they are covered with two inch planks, nailed down when three sleepers are used; but if there be four or five sleepers, the planks may be confined by two *ribbands* (which are pieces of wood of the same length, but weaker scantling than the sleepers) and the platform racked down with *rack lashings* at the proper intervals.

A *rack lashing* consists of a piece of 2-inch rope about 9 feet long, which is fastened to a stick 15 inches long, 2 inches wide at the head, with a hole in it to receive the lashing, and tapering to a blunt point: it is passed round the timber, and sleeper beneath, then twice round itself. The end of the stick is then put into the loose gromet so formed, and twisted round until the whole is firmly secured, when the stick is turned flat on the upper piece of scantling.

The gun, and mortar platforms for sieges are now made rectangular: the dimensions of the former are 15 feet long by 10 feet 6 inches broad; those of a mortar platform are 7 feet 6 inches long by 6 feet 6 inches broad. Mortar platforms are laid exactly horizontal, the front part being placed 5 feet within the foot of the interior slope of the parapet.

Madras platforms consist of two stout planks about 12 feet long; they are supported on two sleepers, having a transom in front. The planks are secured with a moveable bolt, or pivot to the front transom, slide freely on the sleepers, and are connected together in rear by two cross pieces parallel to the rear sleeper, one in front, and the other in rear of it. To the centre of these two cross pieces is bolted another 12-feet plank, called the trail-piece, of a width equal to the distance between the cheeks of a siege-carriage, which is supported on a sleeper in the rear. When the gun is to be traversed, the whole platform is moved on the sleepers on the pivots in front. These platforms are chiefly intended for a direct fire. Two wedges are required for this platform to form inclined planes for the wheels, in running the gun on, or off the platform. Each wedge is of elm, 3 inches thick, 2½ feet long, and 1 foot wide, with a block to give the requisite height, the block being 12 inches long, 4 thick, and 7 in extreme height.

Alderson's platform.

The platform invented by Colonel Alderson, R.E., is 15 feet long, by 9 feet wide; and is composed of 46 similar pieces of timber (baulks) each measuring 9 feet × 5 inches × 3½ inches. Of these, ten are used as sleepers, and the remainder as planking. The weight of the platform (when 15 feet long and 9 feet wide) for guns is 15 cwt. 2 qrs. 14 lb. By addition of the small beams, this platform may easily be extended from 15 to 18 feet.

Dimensions, and Weight of Platforms, for Guns, &c.

Nature of Platform, and articles required.	Number.	Length.		Breadth.		Thickness.		Weight.		
		ft.	in.	ft.	in.	ft.	in.	cwt.	qr.	lb.
GUN, AND HOWITZER.										
Sleepers	5	15			5		5	4	2	1
Planks	20	10	6		9		2	7	3	22
Ribbands.	2	15			4		4	1	0	18
Rack-sticks, and lashings										10
Total weight . .								13	2	23
MORTAR.										
Covered with oak planks.										
Sleepers	7	7	6		6		6	3	3	7
Planks	10	6	6		9		3	5	1	22
Ribbands.	2	7	6		4		4		2	10
Rack-sticks	10	1	3							15
Total weight . .								9	3	26
Made entirely of fir.										
Sleepers	7	7	6		6		6	3	3	7
Planks	8	6	6		11¼		4	4	2	18
Ribbands.	2	7	6		4		4		2	10
Rack-sticks	8									12
Total weight . .								9	0	19
MADRAS.										
Wood-work.										
Side-pieces	2	12	6	1	0		4	3	0	18
Trail-piece	1	12		1	4		4	1	1	3
Fore transom . . .	1	7			6		6		2	19
Hind transoms . . .	2	6	6		9		3		2	20
Sleepers	3	9			6		6	2	0	16
Wedges	2								2	7
Iron-work.										
Long bolts, ⅞-in. diameter	2		11½							6
Short bolts, ditto . .	6		7½							11
Total weight . .								8	2	16

GUN, AND HOWITZER PLATFORM.

For carrying this platform, two men are required for each sleeper; one man for each plank, and ribband. The non-commissioned officer carries the rack sticks.

A platform may be laid down in an hour by expert men, and may be dismantled in three minutes.

MORTAR PLATFORM.

Detailed as above. One non-commissioned officer, and seventeen men carry the platform. *Time required for laying down, and dismantling*, similar to the above.

MADRAS PLATFORM.

In an elevated battery, the platform may be laid down by expert men in half an hour, *and may be dismantled* in three minutes.

BREACH.

The best place for making a breach, in ravelins, bastions, &c., is about thirty yards from their salient angles. The batteries should commence by marking out by their fire the extent of the breach intended to be made, first by striking out a horizontal line as near the bottom of the revetment as possible, and afterwards two others perpendicular to, and at the extremities of this line. Should the breach be required to be extensive, it will be necessary to form intermediate lines. Then, by continuing to deepen these two or more cuts, and occasionally firing salvoes at the part to be brought down, the wall will give way in a mass. The guns must, however, at first fire low, and gradually advance upwards until the breach is effected; and when the wall has given way, the firing should be continued until the slope of the breach is made practicable.

TO BURST OPEN GATES OF FORTRESSES, ETC.

A leathern bag, containing about 50 lb. of powder, should be hooked upon the gate, as near the centre as possible (or be laid on the ground, close to the bottom of the gate, and tamped with sods, &c.), and be fired by means of a piece of portfire, or match, passed through a hole in the bottom of the bag.

SCALING LADDERS.

Scaling ladders are made in portions, 12 feet, and 7½ feet long; which are joined together by placing the end of one portion into staples at the end of another, and securing them together with a lashing of rope. Four men are sufficient to carry an 18 feet scaling ladder.

FORTIFICATION.

Offensive fortification is the art of conducting a siege.

Defensive fortification comprehends military architecture, and is the art of securing, or protecting a place by works, to resist a siege.

Natural fortification consists of obstacles, such as marshes, mountain passes, &c., which are found in some countries, and should be taken advantage of to impede the approaches of an enemy.

Artificial fortification comprises those works which are constructed to defend a place.

Permanent fortification is the art of putting towns, &c., into such a state as at all times to be prepared to resist the attack of an enemy.

Field fortification is the method of fortifying a camp, or position, buildings, &c., and it includes the construction of redoubts, entrenchments, &c. Works of this nature are considered as temporary.

Irregular fortification is the art of fortifying a place of an irregular figure, situated where the country does not admit of giving to the several works their due proportion according to rule.

A Command is the vertical elevation of one work above another, or above the country.

A Command in front is when an eminence is directly facing the work which it commands.

A Command in the rear, or reverse, is when any eminence is directly behind the work which it commands.

A Command by enfilade is when an eminence is situated in the prolongation of any line of a work, and a considerable part of it may be seen from thence; this line will be subject to enfilade, and such a command is the most dangerous.

The Rampart (A T R) is an elevation of earth, obtained from the excavation of the ditch; and is that part of the fortification which is situated between the ditch, and the town; consisting of an interior slope, terreplein, banquette, parapet, and exterior slope or escarp.—(*Vide Plate.*)

The Interior slope (A) is the inclination of earth nearest to the town.

The Terreplein (T) is the upper part of the rampart, which remains after having constructed the parapet.

The Parapet (R) is a mass of earth elevated on the terreplein of the rampart, on the side towards the country; being from 18 to 22 feet thick, and from 6 to 8 feet high. The top is formed with a slight declivity towards the country, which is called the *superior slope, or plunge.*

The Banquette is an elevation of earth, or step, on which the soldiers stand to fire over the parapet.

The Revetment is the masonry which retains the earth of the rampart on its exterior side. It is about 5 feet thick at the top, and its slope is one fifth, or one sixth its height.

The Berm is a space, or path, sometimes left between the exterior slope of the rampart, and the ditch. It serves as a communication round the works, and prevents the earth falling into the ditch.

The Tablette is a flat coping-stone, on the exterior of the top of the escarp of whole revetment.

The Cordon is a semi-circular projection of stone, whose diameter is about one foot, placed at the top of the slope of the revetment of the escarp.

The Escarp (a) is the exterior slope, or wall of the rampart.

The Counterscarp (b) is the wall, or slope of the ditch, opposite to the escarp.

The Faces of a work (p q) are those parts which form a salient angle, projecting towards the country.

The Flank (q G) is the part of a work so disposed as to defend another; joining the face of a bastion to the curtain, &c.

The Bastion (M L) is a work composed of two faces, and two flanks. Bastions are joined by curtains, and are constructed salient, and with flanks, in order that the whole escarp may be seen, and that a reciprocal defence may be obtained.

Bastions are of various kinds—viz., full (M), empty (L), also flat, detached, demi, and tower bastions.

A Full bastion (M) is when the terreplein occupies all the interior space of the bastion. From the description of this bastion, that of all the others may be ascertained, according to their distinctive appellations.

The Curtain (G R H) is that part of the rampart which lies between two bastions, and joins the flanks thereof.

A Front of fortification consists of two half bastions, and a curtain.

The Ditch (B) is an excavation from 12 to 24 feet deep, and from 90 to 150 feet broad, surrounding the rampart. The side of the ditch nearest the place forms the escarp (a); and the opposite part, the counterscarp (b) is made circular opposite to the salient angles of the works.

The Covered way (V) is a space of about 30 feet broad, extending round the counterscarp of the ditch, being covered by a parapet from 7 to 9 feet high, with a banquette.

The Glacis (X) is the superior part of the parapet of the covered way, forming a gentle slope towards the country, and terminating at from 120 to 180 feet; it covers the revetment of the body of the place.

The Places of arms of the covered way are spaces contrived in the salient, and re-entering angles of it; those (c) in the re-entering angles flank the branches of it, and contain troops for sallies, and its defence; and those (P) in the salient angles serve for assembling the Troops destined for the defence of the covered way.

The Sallyports are openings cut in the glacis, at the faces of the re-entering places of arms, and at the branches of the covered way. They are used in making sallies from the covered way.

The Traverses (n) in the covered way, are parapets which cross the breadth of it at the salient, and re-entering places of arms, &c. They cover the troops who are drawn up behind the parapet of the covered way, from the enfilade fire of the enemy. There are passages cut in the parapet of the covered way, close to the traverses, in order to form a communication from one part of the covered way to another: these passages are about 6 feet wide, and are provided with gates.

A Citadel is a fortress joined to the works of a place, and is fortified both towards the town, and country. It should always be situated on the most commanding ground, serving to keep the inhabitants in awe, and, should the town be taken, it becomes a retreat for the garrison.

The Esplanade is a space of even ground, clear of buildings, situated between the town, and citadel.

The Body of the place (or *Enceinte*) consists of the works next to, and surrounding the town, in the form of a polygon, whether regular, or irregular.

Outworks are these works which are constructed beyond the body of the place, such as tenailles, ravelins, &c.

The Tenaille (D) consists of two faces, and a small curtain. It is constructed between the flanks of the bastions in front of the curtain, and has a terreplein, parapet, and banquette.

The Ravelin (P) is constructed opposite the curtain, (in front of the tenaille,) is composed of two faces, which form a salient angle towards the country, and of two demi-gorges formed by the counterscarp.

A Horn-work is composed of two half bastions, and a curtain, with two long sides directed upon the faces of the bastions, or ravelins, so as to be defended from them.

A Crown-work is composed of a bastion between two curtains, which are terminated by half bastions. It is joined to the body of the place by two long sides.

Lunettes, and *Tenaillons* are works constructed on each side of ravelins, consisting of two faces.

A Flèche, or *Arrow,* is constructed along the foot of the glacis before the re-entering, and salient places of arms. It consists of a parapet, whose faces form a salient angle, and are about 120 feet long, and it has a communication with the covered way, cut through the glacis.

The Caponniere (Y) is a work intended to cover a passage across the ditch. That from the tenaille to the gorge of the ravelin is a road about 30 feet wide, covered on each side by a parapet 7½ feet high, its superior slope terminating in a glacis about 60 feet wide.

A Cunette is a small ditch made in the middle of a dry ditch, to drain off the water from the place, &c.

A Batardeau (e) is a solid piece of masonry, 7 or 8 feet thick, crossing the whole breadth of the ditch opposite the flanked angles of the bastions. It retains the water in those parts of the ditch which require to be inundated.

A Ramp (t) is a road cut in the interior slope of the rampart, forming a communication from the town, &c., to the terreplein.

A Cavalier is a work constructed upon the terreplein of a full bastion, being from 8 to 12 feet above the rampart, with a parapet 6 feet high. Its use is to command some rising ground within cannon-shot, and to serve as a traverse for preventing the neighbouring curtains from being enfiladed.

Parallels, or *Places of arms*, thrown up at sieges, are trenches formed to connect together the several approaches to a besieged place.

Zig-zags, or *Boyeaux of communication*, are trenches made for the approaches from the parallels to the besieged place. They are generally 3 feet deep, and have a parapet, and banquette.

A Redan consists of two faces forming a salient angle (which should not be less than 60°) with parapet, &c.*

A Lunette has two faces, similar to the redan, and also two flanks.*

A Redoubt is a square, polygonal, or circular field fort.*

A Star fort consists of a succession of salient, and re-entering angles, formed on the sides of a polygon. These forts are usually constructed on a triangle (when they have six salient points), or a square (having eight salient points).*

Têtes de pont, or *Bridge heads*, consist of redans, &c., which are constructed upon the banks of rivers, to protect the passage across them.*

Lines are formed for the entrenchment of armies, and are composed of a succession of redans, &c., joined by curtains, which should not be more than 120 yards distant from each other, to afford mutual protection, and defence.*

An Epaulment is an elevation of earth thrown up to cover troops from a flanking fire.

Loop-holes are oblong holes, from 15 to 18 inches long, 6 inches wide within, and 2 or 3 without. They are cut through timber, or masonry, for the services of small arms.

Palisades are stakes of strong wood, 8 or 9 feet long, and 6 inches thick, fixed about 3 feet in the ground, and 3 or 4 inches asunder.

Fraises are a kind of palisades, placed horizontally, or obliquely in the exterior slope of ramparts.

Chevaux de frise consist of a piece of timber from 9 to 12 feet long, and about six inches in diameter, into which staves are inserted crossways, about 9 inches asunder, about 2 inches thick, 6 feet long, and pointed at the end, if not shod with iron. Their use is to stop up a breach, defend a passage, or form an entrenchment against cavalry. Chevaux de frise are sometimes made entirely of iron.

Abattis consist of trees with their branches shortened, and sharpened at the ends: they are used instead of chevaux de frise on an emergency.

Hurdles are about 3 feet high, and 2 broad, and are used in sieges to stop up breaches, &c.

Trous de loup are holes dug in the ground in the form of an inverted cone, about 6 feet deep, and 4½ in diameter at the top, having a picket fixed in the centre of the bottom, 6 feet long, and

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* *Vide* FIELD FORTIFICATION, pages 252, 253, 254, 255.

4 or 6 inches square, the point being on a level with the upper surface of the ground. These pits are used to prevent the approach of bodies of cavalry.

PERMANENT FORTIFICATION.

Remarks, and general rules.

The ground plan, and relief of bastioned fortifications are mutually dependent on each other; and, as a variety of causes occur to influence both according to the various sites occupied, it is impossible to give them any fixed arrangement, and dimensions, applicable under all circumstances. However, under the supposition that the site to be fortified is a horizontal plane, a great number, and variety of systems have been proposed at different times; almost every author, who has treated of fortification, having invented one, at least, of his own. Notwithstanding this diversity of opinion, as to the best system, all agree that the following general principles should not be lost sight of in the construction of fortifications.

1. Salient angles should be as large as possible, and never less than 60°. The larger they are, the smaller will be the space in front undefended by direct fire. If less than 60°, the salients of earth are too acute to stand firmly for any length of time; and the angles of masonry are easily damaged; besides which, the space within the parapets becomes too restricted to admit of a gun being worked near the angle.

2. Angles of defence should be right angles, or slightly obtuse. If less than right angles, the fire from the flanking works might injure the defenders of the works they flank; as troops generally, and more particularly at night, fire in a direction perpendicular to the parapet; and if too obtuse, the fire might be directed wide of its object. Besides, embrasures should be cut as direct as possible; as the more they are oblique, the more they weaken the parapet.

3. The length of the lines of defence shall be such, that the works defended may be within the effective range of the projectiles used.

4. The works should be so disposed that the assailants may not be able to obtain cover in any part of the exterior, within range of the projectiles of the defenders.

5. The escarps of the body of the place should be of such height, or construction, as to be secure against escalade.

6. The masonry should be sufficiently covered from the view of the enemy, to prevent his making a practicable breach from a distance.

7. The interior of every work should be completely covered from the view of an enemy outside it; so that he may not be able to fire directly into any part of it. Interior works should therefore have a command over those in front of them, at least equal to the height which a besieger can give to the parapets of his lodgments, and which is seldom less than 3 feet.

8. Every opportunity should be seized of so directing the faces of

works that an enemy may not have it in his power to enfilade them by ricochet fire.

9. In the general construction of fortifications the salients should be few, and sufficiently prominent to force the besieger to take them before he can attack the re-entering parts. The object of this is to reduce the number of points of attack, as, the fewer they are, the less advantage an assailant derives from his numerical superiority.

10. Permanent fortifications must be considered very incomplete without a sufficiency of casemated cover for the sick, and wounded, and for the portion of the garrison off duty. The magazines of ammunition and provisions, should also be secure from the effects of shells; and the supply of water ample, and certain.

11. Small enclosed works, in which the defenders must be crowded, without cover from vertical fire, should never be employed in permanent fortification. The strength they impart can never make up for the loss the garrison must suffer by them.

12. Outworks, and detached works should have easy communications with the main work, to admit of their garrisons receiving reinforcements, or supplies, when necessary; and to enable them to retreat, when the works are no longer tenable.

13. Every enclosed defensive work of importance should, if possible, be provided with a keep, or citadel, or interior retrenchment, to which the garrison may retire when the main enclosure (or enceinte) is forced.

14. Outworks, and detached works near the body of the place, should be so constructed that the enemy, when he has taken them, may not be able to use them as defensive works.

15. Outworks, and detached works, should always be of sufficient strength to force the enemy to make *regular* attacks on them. Advanced works of a weak construction are likely to do more harm than good; for the troops of the garrison seeing them taken with comparative facility, would naturally lose confidence in the strength of their remaining defences, while that of the assailants would be increased by early success.

16. All fortifications should be provided with means of egress, and ingress, to enable the garrison to assume the offensive, whenever opportunities offer; and to admit reinforcements into the fortress.

17. There are very few fortified places that agree with any published system, though some resemble one or other of the systems, or consist of combinations, or modifications of them. The systems which have been wholly, or partly carried into execution are, of course, the most interesting, and form valuable subjects of study. A knowledge of their advantages, and defects, and the best methods of attacking, and defending them, will enable the military student properly to appreciate works which have been, or are to be constructed; and the operations by which fortresses have been, or may be captured.

VAUBAN'S FIRST SYSTEM.

To describe three Fronts of fortification, on a hexagon. Vide Plate.

With a radius of 360 yards, the length of the exterior side of the fortification (taken from a scale of equal parts), describe a semicircle, which divide into three equal parts, and draw lines to the points of division; thus forming *three exterior sides.* Bisect each of these by perpendiculars drawn to the centre of the polygon, on which set off $\frac{1}{6}$th of the exterior side, (if a hexagon,)* through which points draw *the Lines of defence;* on these set off $\frac{2}{7}$ths of the exterior side, from the angles of the circumference, for the length of the faces of the bastions; with radius of the distance between the two faces describe arcs joining the lines of defence, and draw the chord of these arcs for *the flanks of the bastions*; a line joining the interior extremities of the flanks will give the length of *the curtains.*

[*Or, to describe one Front of fortification.*

For the exterior side, draw a line 360 yards in length, at the ends of which, lines are to be directed to the centre of the polygon, at the angle required; (*vide* PRACTICAL GEOMETRY—*To find the angles at the centre, and circumference of a regular polygon,*) then bisect the exterior side, and draw the perpendicular, &c., &c., as described, above, for the construction on a hexagon.]

Main ditch.

From the salient angles of the bastions, with 38 yards as a radius, describe arcs, to which draw tangents, directed to the angles of the shoulders of the bastions.

The Tenaille.

Draw lines parallel to the lines of defence, at the distance of 16 yards, for the faces of the work; its flanks, and curtain are constructed parallel to the flanks of the bastions, and curtain, at the distance of 11 yards.

The Ravelin.

From the re-entering angle of the counterscarp, make the capital of the ravelin 80 yards in length, and from its summit draw lines to points, on the faces of the bastions, 11 yards from the angle of the shoulder; the junction of these lines, and the counterscarp of the main ditch will determine the length of the faces of the ravelin. The gorge is formed by drawing lines 24 yards from the re-entering angle of the counterscarp to the intersection of the perpendicular, and the exterior side. From the salient angle of the ravelin, with a radius of 24 yards, describe an arc, to which draw tangents parallel to the faces, for the breadth of the ditch.

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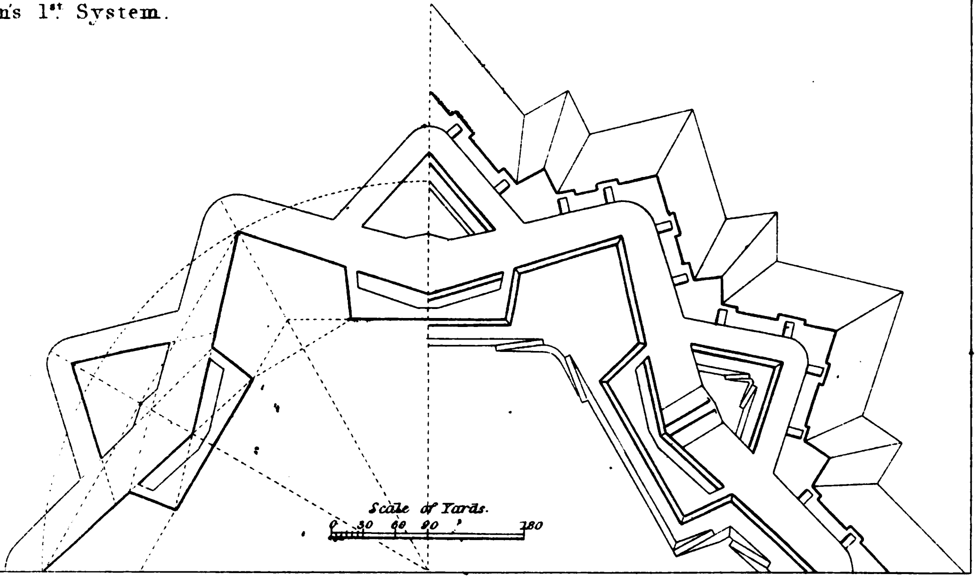
* For a square, the length of the perpendicular is 1-8th the exterior side; for a pentagon 1-7th; for the hexagon, and other polygons, 1-6th.

Vauban's 1st. System.



J. W. Lowry fc.

From the outline of the works draw the following parallels inwards:—

Rampart.

1. At the distance of 6 yards, for the thickness of the parapet.
2. From which 12 yards, for the breadth of the terreplein.
3. From which 6 yards, for the breadth of the interior slope.

Tenaille.

Draw lines parallel to the faces, at the distance of 6 yards, for the parapet.

Ravelin.

To the faces of the work draw the following parallels:—

1. At the distance of 6 yards, for the parapet.
2. From which 8 yards, for the terreplein.
3. From which 5 yards, for the interior slope.

Covered way.

Draw lines parallel to the counterscarp, at the distance of 11 yards, for the breadth of the covered way.

Salient places of arms.

These are formed by the salients of the branches of the covered way.

Re-entering places of arms.

Set off 40 yards on each side of the re-entering angle of the counterscarp for their demi-gorges, from which points draw their faces at an angle of 100 degrees.

Glacis.

For its breadth, draw parallels to the branches of the covered way, and the re-entering places of arms, at the distance of 50 yards.

Traverses.

Those at the re-entering places of arms are erected perpendicular to the covered way; those at the salient places of arms are formed on the prolongation of the faces of the bastions, and ravelins, across the covered way; all the traverses are 6 yards thick at the top. The passages, cut out of the glacis, to enable the troops to pass round the traverses, are 4 yards wide.

Ramps.

Flanked angle of the empty bastion.—From the angle of the interior slope set off 16 yards on each side, from which points draw lines 42 yards in length diagonally along the interior slope for the length of the ramps; to which draw parallels, 4 yards distant, for their breadth; erect perpendiculars from the points (16 yards from the angle) until they intersect each other, from which point as a centre, with radius of the distance between the ramps, describe an arc joining the head of the ramps of the two faces; concentric to which, with a radius 6 yards less than the former, describe another arc, to which draw tangents from the termination of the ramps, representing their slopes.

Gorge of the full bastion.—From the angle of the interior slope, set off 16 yards on each side, from which points draw lines 42 yards in length diagonally along the interior slope; draw parallels to these at the distance of 5 yards, for the breadth of the ramps; erect perpendiculars at their head, from the intersection of which as a centre, with radius of the distance between them, describe an arc, parallel to which, with radius 6 yards less, describe another arc, to which draw tangents, completing the interior slope of the ramps.

Flank of the empty bastion.—Set off 42 yards, from the angle of the flank of the interior slope, diagonally along the slope, for the length of the ramp, to which draw a parallel line 5 yards distant, for the breadth, prolonging it to the top of the interior slope, and setting off 6 yards for the interior slope at the head of the ramp; to which point, from the end of the ramp, draw a line; and also from the same point draw another line parallel to the prolongation of the side of the ramp, and joining the interior slope of the face of the bastion.

Ravelin.—From the angle of the interior slope, set off 12 yards on each side; from these points draw lines 30 yards in length, diagonally along the interior slope, for the length of the ramps; to which draw parallels 4 yards distant for their breadth; erect perpendiculars at the commencement of the ramps, and from their intersection, as a centre, with radius of the distance from the ramps, describe an arc joining the two ramps: also from the junction of the perpendiculars draw lines to the termination of the ramps, for their slopes.

Caponniere.

Make the passage of this work 10 yards wide, including the banquette on each side: the superior slope of each parapet terminates at 20 yards' distanee.

Bridges, and communications.

These are about 14 feet wide.

Stairs, or *Pas de souris.*

These steps of masonry are made at the gorges of the several works, and at the salient, and re-entering angles of the counterscarp. Those at the salients are generally 24 feet long, and at the re-entering angles 30 feet; they are 5 feet wide, and their steps 1 foot distant from each other.

Sally-ports.

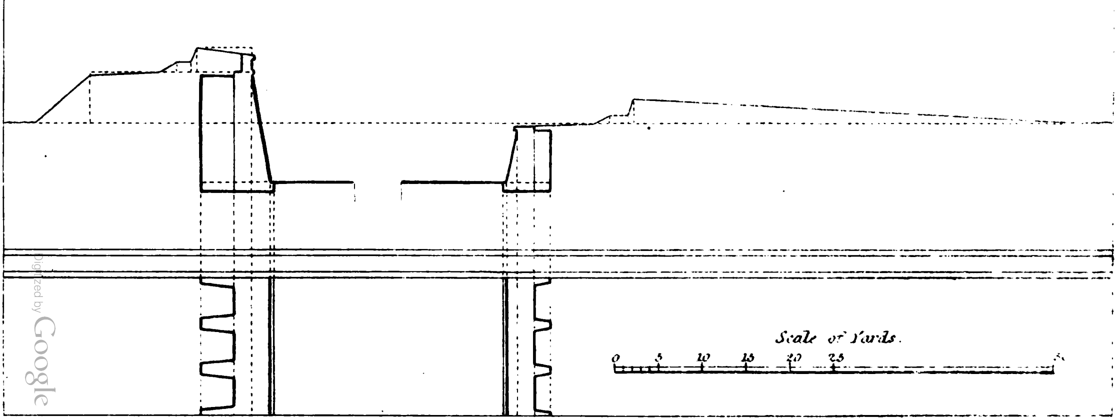
These passages, cut through the glacis, are about 12 feet wide, and 18 feet long.

PROFILE, OR SECTION OF VAUBAN'S FIRST SYSTEM.

Construction.

The interior slope of the rampart has a base of 18 feet, and a perpendicular height of 17 feet 6 inches.

Profile
of
Vauban's 1st System.



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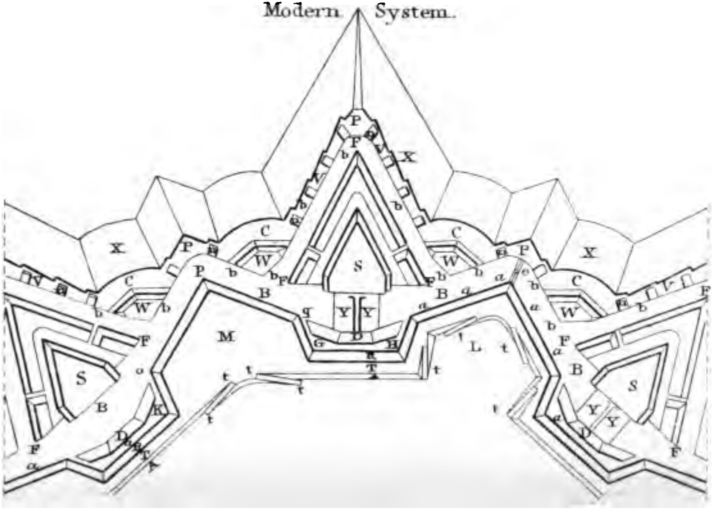
FORTIFICATION.

Modern System.



The terreplein has a breadth of 25½ feet, its height being 18 feet sloping to 17 feet 6 inches, the height of the interior slope.

The banquette is 3 feet in height, the tread 4 feet wide, and the slope 5 feet wide.

The parapet is 4 feet 6 inches higher than the banquette, its interior slope is 18 inches, its thickness 18 feet, and its superior slope has a declivity of 3 feet; the revetment is 3 feet thick.

The escarp has a perpendicular height of 36 feet, measuring from the cordon to the bottom of the ditch.

The tablette, or coping-stone, at the top of the revetment, has a projection of 6 inches square.

The cordon is semicircular, its radius being 6 inches.

The slope of the escarp is 6 feet, the thickness of its revetment at the top 5 feet, and at the bottom 11 feet.

The counterfort joins the escarp: it is 1 foot lower than the top of it, 9 feet wide, and it extends to the bottom of the foundation, which is 3 feet below the bottom of the escarp; the retreat, or lessening, has a width of 1 foot.

The ditch is 38 yards wide, from the salient angle of the bastion.

The counterscarp is 17 feet 6 inches in perpendicular height, its slope being 3 feet, and its thickness at top 3 feet, the bottom, therefore, having a thickness of 6 feet; the foundation is 3 feet; and the retreat 1 foot.

The terreplein of the covered way is 20½ feet wide, and its slope is 6 inches. The banquette is 3 feet high, its tread 5 feet, and its slope 6 feet. The parapet is 4 feet 6 inches above the banquette, and its interior slope is 18 inches. The glacis, which forms the superior slope of the parapet of the covered way, is 50 yards in breadth.

The counterfort of the counterscarp is 5 feet in thickness, being 1 foot lower than the top of the counterscarp, and extending as low as the foundation of it.

The counterforts of the escarp, and counterscarp are 15 feet distant from centre to centre of each other, those of the escarp being at the end adjoining it 5 feet 6 inches, and at the termination 3 feet 8 inches thick; those of the counterscarp being in thickness at the larger part 3 feet 6 inches, and at the smaller 2 feet 4 inches.

Vide Plate.

MODERN SYSTEM.

A	Interior slope.	p q	Face of bastion.
T	Terreplein of rampart.	q G	Flank of bastion.
R	Parapet of rampart.	K o p q G	Outline of bastion.
A T R	Rampart.	G H	Curtain.
a a a a	Escarp, or exterior slope of rampart.	t	Ramps.
		B	Ditch.
M	Full bastion.	D	Tenaille
L	Empty bastion.	Y	Caponniere.

e	Batardeau.	c	Re-entering places of arms.
F F F	Ravelin.	W	Redoubt in ditto.
S	Redoubt in ravelin.	P	Salient places of arms.
b	Counterscarp.	V	Covered way.
a	Traverses in covered way.	X	Glacis.

FIELD FORTIFICATION.

REMARKS, AND GENERAL RULES.

1. The size of a work depends in general upon the number of men who are to defend it. If labour is the sole object of attention, the advantage must necessarily be the greater in proportion as the size of the work is less; but if the accommodation of the troops is only to be considered, the advantage depends greatly upon occupying much ground.

2. The form of the work should be such as to contain the greatest surface with the least perimeter. By an adherence to this maxim, we obtain the greatest accommodation for the troops with the least labour. The form of a field work seldom depends upon choice, but generally upon the spot where it is to be raised, the purposes for which it is to be constructed, and the nature of the ground in the vicinity.

3. The interior of the work ought to be so covered by the parapet, that the men within, except when on the banquette, may not be seen from any part without, at the distance of cannon-shot.

4. The circumjacent ground (to as great a distance as possible) ought to be cleared, that the enemy may not conceal, or shelter himself against the fire from behind the parapet. The nearer to the work that the enemy can find cover, the more advantageously he can form his dispositions; and, as his attacks may consequently be made with greater vigour, and be more readily supported, the success will be the more probable.

5. The flanking parts ought to be sufficiently capacious to contain all the men required for the defence of the flanked portions of the work.

6. The flanking parts ought to have nearly a direct view of those flanked; that is, the defence should be nearly at right angles, the most advantageous angle being 100 degrees.

7. The parts flanked ought to be within musket fire of their flanking parts.

8. The fire ought to be equally distributed, that every part of the work may be equally defended.

9. The work ought to be equally strong in all its parts, that it may everywhere equally resist the assaults of the enemy; and the parapet should be thick enough to withstand the shot fired against it.

10. The dimensions of the parapet should not only be sufficient to secure, and cover the troops within the work, but ought also to be of such a form as to afford a full view of the enemy in his approach; and

at the same time discover, as little as possible, the men employed for its defence.

Capacity of Field works.

The perimeter of a Field work, and the number of men to defend it, should bear a just proportion to each other, according to the nature, and object of the work: *Linear measurement* (on the crest of the parapet) 1 yard being allowed for each man, or for each file of men; and 5 or 6 yards for each gun: *Superficial measurement* (area within the banquette) 2 square yards for each man, and 36 square yards for each gun. Various authors, English and French, have published rules for determining the size of Field works, and there is a great discrepancy in their conclusions: the following rule (adopted at the Royal Military College) for computing the area, and perimeter of a square Redoubt will, however, meet the general requirements of these works.

Multiply the given number of men by 2, and the number of guns by 36, for the number of square yards which the work ought to contain within the foot of its banquette: the square root of the product will be the length, in yards, of the side of the square forming that area: add to this result, the breadth of the two interior slopes of the parapets, and of two banquettes, with their slopes (about 7 yards), and the length of the side of the square, formed by the crest of the parapet, will thus be determined.

Rules.

1. *To find the quantity of earth* required for the parapet, and banquette of a field work, &c.

Divide the parapet, and banquette into trapezoids, and triangles; compute the contents of each separately (*by the rules in* MENSURATION OF PLANES), and the sum of them will be the superficial content of a section of the parapet, and banquette. Multiply this by the length of the periphery of the redoubt, battery, &c., for the solid content of the parapet, and banquette.

In square redoubts, or works having salient angles, if the areas of the sections of the parapet, and ditch, are made nearly equal, there will be too much earth; were the angles of the plan re-entering, instead of salient, the result would be reversed. Bearing this in mind, previous to commencing the excavation of the ditch, an allowance must be made to prevent any excess, or deficiency of earth for the parapet, and banquette.

2. *To find, rapidly*, the quantity of earth required for a parapet, and banquette.

Multiply the height of the crest of the parapet, into the sum of the bases of the superior, and exterior slopes; which will give the superficial content, very nearly.

3. *To compute the superficial content of the ditch.*

Multiply the depth into the breadth at bottom, to which product add the areas of the escarp, and counterscarp, for the content required.

4. *To find the breadth of the ditch*, of the usual form.

Divide the area of the section of the parapet by the intended depth of the ditch, and the quotient will be the mean breadth of the ditch; to this add half the sum of the bases of the slopes of the escarp, and counterscarp, for the breadth at top, and deduct the same for the breadth at bottom.

5. *To find the breadth of the ditch*, having a triangular section.

Divide the area of the section of the parapet by half the given depth of the ditch, and the quotient will be the required breadth at the top.

Construction of Field works.—Vide Plate.

Fig. 1. *The redan.*

Draw a base line, 60 yards, from the centre of which erect a perpendicular, 40 yards; join the terminations of the base, and perpendicular, which will form the crest of the parapet of the work.

Fig. 2. *The lunette.*

Construct a redan (*vide No.* 1), base 80 yards, perpendicular 50 yards: make the faces of the lunette 45 yards in length, and draw the flanks to points on the base line, 30 yards, from the perpendicular.

Fig. 3. *The square redoubt.*

Construct a square, each side 40 yards (*vide* PRACTICAL GEOMETRY). To form additional faces when required, bisect the side of the square, draw perpendiculars inwards equal to ⅛th of the side, and join the termination of the perpendiculars, and the sides of the square, thus forming a double number of faces.

Fig. 4. *The pentagonal redoubt.*

Describe a circle, radius 30 yards, and construct a pentagon in the circle (*vide* PRACTICAL GEOMETRY), thus forming the crest of the parapet of the redoubt.

Fig. 5. *The hexagonal redoubt.*

Describe a circle, radius 30 yards, and construct a hexagon within it (*vide* PRACTICAL GEOMETRY); the sides of which form the crest of the parapet of the work.

Fig. 6. *The circular redoubt.*

Describe a circle, radius 30 yards, which will form the crest of the parapet of the redoubt.

Fig. 7. *The star fort, with six points.*

Construct an equilateral triangle, and divide each side, 75 yards, into three equal parts: form also an equilateral triangle on the central portion of each side, 25 yards, and the crest of the parapet of the fort will be traced.

Fig. 8. *The star fort, with eight points.*

Construct a square: divide each side, 60 yards, into three equal

FIELD FORTIFICATION.

Fig. 1.

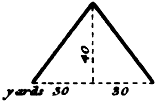


Fig. 2.

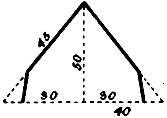


Fig. 3.

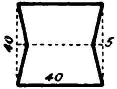


Fig. 4.

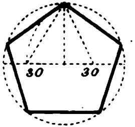


Fig. 5.

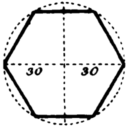


Fig. 6.

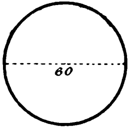


Fig. 7.

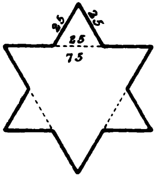


Fig. 8.

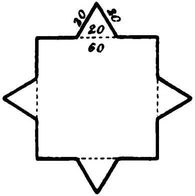


Fig. 9.

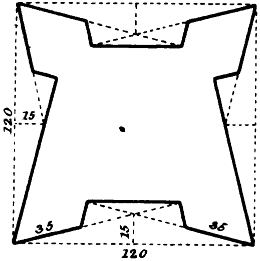


Fig. 10.

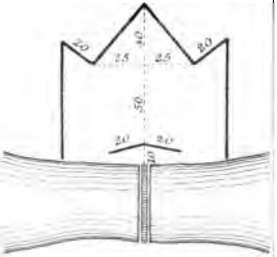


Fig. 11.

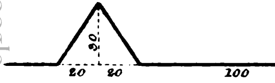


Fig. 12.

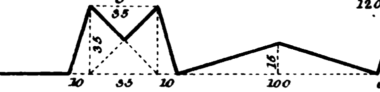
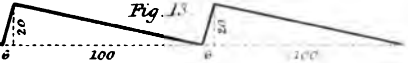


Fig. 13.



J. W. Lowry fc.

parts, and on the central portion, 20 yards, describe an equilateral triangle: the periphery of the fort will thus be obtained.

Fig. 9. *The field fort, with bastions, and half bastions.*

Construct a square; from the centre of each side, 120 yards, drop a perpendicular equal to one-eighth of the side, through the extremity of which, from the angles of the square, draw the lines of defence; make the faces of the bastions, and half bastions, two-sevenths of the exterior side, and draw the flanks perpendicular to their respective lines of defence.

Fig. 10. *The bridge head,* or *tête du pont.*

Construct a redan, base 50 yards, perpendicular 30 yards, at an appropriate distance from the bridge, 50 yards; draw flanks, 20 yards, perpendicular to the faces, and from their termination draw lines to the river parallel to the capital of the work. To strengthen the interior defence of the tête du pont, construct a flêche, faces 20 yards each, and 10 yards in front of the bridge, which is 4 yards wide.

In the construction of bridge heads, the foregoing Figures may be employed when expedient; the simplest form, the redan, being for light bridges, and the more perfect defence, the bastioned front, or fronts, for bridges of material consequence.

Figs. 11, 12, 13. *Lines.—Vide Plate.*

Fig. 11. Construct a redan, base 40 yards, perpendicular 30 yards; which join by a curtain 100 yards, to a queue d'aronde.

Fig. 12. Side of square, 35 yards, and lines drawn from summit to points on the curtains 10 yards. To increase the defence of the next curtain, 100 yards, bisect it by a perpendicular, 15 yards, and draw the two faces. Lengthen the lines by cremaillères.

Fig. 13. Base 100 yards; crochet, base 5 yards; perpendicular 20 yards.

Lines, continuous, are formed by a modification of redans, lunettes, curtains, &c., dependent on the nature of the ground, and the means of defence.

Lines, with intervals, are formed by detached redans, lunettes, &c., within range of each other; the rear works flanking those in front.

Bridges, and passages into field works are from 6 feet, to 12 feet wide, according to the requirements.

Traverses are placed about 9 feet from the slope of the banquette, their length being so regulated as to exclude from the view of the enemy the interior of the field work.

The nature, and form of the field work, or lines, required for the defence of a post, &c., &c., having been determined, the perimeter may be laid down, in conformity to the construction detailed in the foregoing figures: after which the requisite dimensions of the parapet, ditch, &c., (dependent, of course, on the nature of the enemy's ordnance must be taken into consideration, and the quantity of earthwork computed by the *Rules*, pages 251, 252, or by those in PRACTICAL GEOMETRY. The following Table will, however, in many cases be found useful; and, by a judicious adaptation of it, much time may be saved in the computation, and construction of field works.

TABLE,

showing the dimensions, in feet; and the superficial content of earth of banquettes, parapets, and ditches, of field works.

Number.	BANQUETTE.				PARAPET.							Berm.	DITCH.				
	Base of slope.	Tread.	Height.	Superficial content.	Interior slope.		Superior slope.		Exterior slope.		Superficial content.		Breadth at top.	Escarp slope.	Counterscarp slope.	Depth.	Superficial content.
					Height.	Base.	Height.	Base.	Height.	Base.							
1	6	5	3	24	7½	1½	7½	15	5½	5½	120½	3	26	3	3	6	138
2	6	4	3	21	7½	1½	7½	15	5	5	114⅛	3	20	4	4	8	128
3	6	5	3	24	7½	1½	7½	12	5½	5½	101	3	23	3	3	6	120
4	6	4	3	21	7½	1½	7½	12	5	5	98⅜	3	17	4	4	8	104
5	6	4	3	21	7½	1½	7½	9	5½	5½	81¼	3	19	3	3	6	96
6	6	4	3	21	7½	1½	7½	9	5⅓	5⅓	81¼	3	16	4	4	8	96
7	5	4	3	19½	7½	1½	7½	6	6	6	66⅜	2	18	3	3	6	90
8	5	4	3	19½	6	1	6	6	4½	4½	44⅝	2	15	10	5	8	60
9					8	1½	8	12	5⅔	5⅔	102⅜	3	19	3	3	6	96
10					7½	1	7½	9	5⅓	5⅓	78	2	16	4	4	6	72
11					6	1	6	6	4⅔	4⅔	44⅝	2	12	4	3	6	51
12					6	1	6	3	5¼	5¼	33⅚	2	9	6	3	8	36
13	4	4	3	18	7½	1	7½	4	5½	5½	44¼	2	15	10	5	8	60

SIMPLE METHODS OF TRACING FIELD WORKS, ON THE GROUND.

1. *Square redoubt.*

Place pickets in a line (in length conformable to the side of the intended work), at each end of which erect perpendiculars equal in length to the side first marked out, and join the termination of these lines; which will complete the perimeter of the redoubt.

Note.—A perpendicular is raised on a given line, with a chain or cord, by forming a right-angled triangle from the numbers 3, 4, and 5, or any multiples thereof, and extending the cord, &c., so that the base may correspond with the base line of the pickets, and the perpendicular be in the direction of the side required.—*Vide* PRACTICAL GEOMETRY.

2. *Pentagonal redoubt.*

With a chain, tape, or cord, construct, and lay down with pickets five similar, and contiguous triangles, having their bases, which form the sides of the pentagon, in the proportion of 47 to the other two equal sides, the length of each of these being 40.

3. *Hexagonal redoubt.*

From a central point with a chain, or line, construct, and lay down, with pickets, six equilateral, and contiguous triangles, the bases of which will form the required hexagon.

4. *Octagonal redoubt.*

Construct a square (*vide* No. 1), from the centre of each side of which erect perpendiculars outwards, in length proportional to the side as 13 to 60 (nearly 1 to 5); join the extremities, or termination of the perpendiculars, to the angles of the square, which will determine the sides of the octagon.

Note 1.—The directions for the construction of the pentagonal, and hexagonal redoubts are on a small scale; but the redoubts may be increased by the equal extension of the interior sides of the triangles, until the bases are sufficiently long for the periphery of the work required.

Note 2.—By means of the pocket sextant, prismatic compass, or reconnoitring protractor, the pentagonal, hexagonal, and octagonal redoubt may be thus traced on the ground. From a central point place pickets at the requisite distance from each other, and in the direction of lines drawn from the angle of the centre of the intended work. (*Vide* PRACTICAL GEOMETRY. *To find the angles at the centre, and circumference of a polygon.*) Extend these radii equally until the relative distances between them are of the length required to form the sides of the proposed equilateral redoubt.

5. *Front of fortification, for a Field fort.*

Place pickets in a straight line, of the length required for the front of the proposed field work; from the centre of which drop a perpendicular inwards, making it for a square, pentagon, or hexagon, respectively one-eighth, one-seventh, or one-sixth of the exterior side. Direct the lines of defence from the termination of the exterior side to the end of the perpendicular, making the faces of the bastions two-sevenths of the exterior side, and constructing the flanks perpendicular to, and joining the lines of defence. Other fronts are traced by laying down the exterior sides, at the angle of the circumference of the intended polygon (*vide* PRACTICAL GEOMETRY) by means of the prismatic compass, &c., and then proceeding as directed for the former front.

PART XIII.

BRIDGES, AND PONTOONS.

BRIDGES.

1. *To find the number of planks required to form a float, to support a given weight.*

1st. Find the content of one plank (*vide* PRACTICAL GEOMETRY, *Part* 15), and multiply it by the specific gravity of the wood; the product will be the *weight of the timber.*

2nd. Multiply the same solid content by the specific gravity of water; the product will be the *weight of an equal bulk of water.*

Then take the difference of these two products, or weight, and it will be the weight one piece of timber will support without sinking. *Hence by Proportion*, the number required to support the given weight may be found.

Note.—A fir tree, 1 foot square and 25 feet long, will float about 703 pounds.

2. *To find the number of casks required to form a raft to support a given weight.*

1st. Find the solid content of one cask in cubic inches (*vide* PRACTICAL GEOMETRY), and multiply it by the specific gravity of water; the product will be the weight of a quantity of water of equal bulk with the cask.

2nd. From this product, or weight, subtract the weight of the cask, and the remainder will be the weight it will support without sinking. *Then by Proportion*, the number required for the formation of the raft may be found.

3. *To find the number of boats, or pontoons, required to support a given weight.*

The burthen a boat, or pontoon, will support without sinking beyond a given depth (the form of the boat, or pontoon being known) must first be found, thus—

1st. Find the solid content of the part to be sunk, in cubic feet (*vide* PRACTICAL GEOMETRY, *Part* 15), and multiply it by the specific gravity of water (*vide* GRAVITY, *Part* 15).

2nd. Subtract this product from the weight of the boat, or pontoon, and the remainder will be the burthen it will support without sinking beyond the required depth.

Then by Proportion, the number required to support the given weight may be computed.

Note.—In the construction of bridges, should a rope require to be extended across a rapid river, the coil should be placed in the boat (instead of on shore), and be paid out as the boat advances.

PONTOONS.

Those called Blanshard's (from their inventor, M. General Blanshard, Royal Engineers) are of two descriptions.

1.—LARGE PONTOONS.

Displacement of water, 97½ cubic feet, equals 6088 lb., or 54½ cwt.

The buoyant power of a raft of two pontoons, its own weight deducted, is 77 cwt., about one-half of which is a safe load. Each raft, or one carriage load, forms 2 bays, or 20 ft. 8 in. of bridge: its own weight will sink it about 7 or 8 inches. The crew of a raft consists of 6 rowers, and 1 steersman.

At open order the bridge will pass cavalry, field artillery, or infantry with closed files.

At close order the bridge will pass any part of a heavy train.

Dimensions, and weight of cylindrical pontoons, manufactured in the Arsenal at Woolwich.

	Extreme length.		Diameter.		Weight.
	ft.	in.	ft.	in.	cwt.
LARGE PONTOON, With hemispherical ends. .	22	3	2	8	4
SMALL PONTOON, With conical ends	15	0	1	8	1¼

ONE CARRIAGE LOAD.

		Dimensions.								
	Number.	Length.*		Breadth.		Depth.		Weight.		
		ft.	in.	ft.	in.	ft.	in.	cwt.	qrs.	lb.
Pontoons	2	22		2	7	2	7	9	1	9
Baulks	12	14	2		5		3	5	1	1
Chesses	8	12		1	2		1½	1	3	19
Half-chesses	4	11	5				1½	1	3	0
Gunnels	2	12		1	2		4	1	3	19
Side-pieces	5	10	4		5		2½	1	1	0
Anchor	1								3	1
Buoy	1									3
Cable (20 fathoms)	1	168			3		3		1	18
Oars	7	14							3	14
Boat-hook	1	14								7
Lashings: Body	3	8	9		4					20
Lashings: Gunnel	4	15			1		1			8
Lashings: Carriage	4	22			1		1			
Rack-sticks, and lashings	8									14
Buoy-line	1	60			1½		1½			5
Breast-line	1	60			1½		1½			5
								31	1	0
Weight of Carriage	1							13	3	20
Total								45	0	20

2.—SMALL PONTOONS.

Five pontoons, with their appurtenances, form the load of one carriage. Length, 15 feet; diameter, 1 foot 7 inches; displacement, 27½ cubic feet; buoyancy, 1718 lb., or 15¼ cwt., from which deduct 2 cwt. for the weight of pontoon, and share of superstructure. A bridge of this nature is so light that it may be made on shore, and carried by hand entire. It will support as many men as can be placed on it, and, by removing the chesses over the gunnels, it may be bent so as to be passed without difficulty down a steep bank, or counterscarp.

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* The length includes the hemispherical ends.

ONE CARRIAGE LOAD.

	Number.	Dimensions.						Weight.		
		Length.*		Breadth.		Depth.				
		ft.	in.	ft.	in.	ft.	in.	cwt.	qrs.	lb.
Pontoons	5	15		1	7	1	7	5	0	0
Gunnels	5	8	4		9		3		3	12
Baulks	30	6	6		3		1½	1	1	9
Chesses	20	8		1	4		1½	4	0	20
Paddles, used as side-pieces	5								1	27
Rack-sticks, and lashings.	10									6
Carriage lashings . . .	2									5
Anchor, and cable . .	1								2	0
								12	1	23
Weight of the Carriage .	1							9	0	0
Total								21	1	23

* The length includes the ends.

PART XIV.

FIREWORKS.

CASES.

Cases are made of different dimensions according to the description of firework required, and the length of time it is intended to burn.

The following is a description of the method generally adopted in making cases.

The "Former" is a cylinder of such size as may be required, of wood, solid brass, or brass tubing: the last is to be preferred on account of its lightness and non-liability to alter its shape like wood.

The paper used is good strong brown paper, weighing not less than 84 lb. to the ream—cut up into slips, the width of paper corresponding to the length of the case. As the paper is always tougher in one direction than the other, care must be taken to cut it so as to roll up in the direction in which the paper is tough.

A slab of slate, about 18 inches wide and 4 feet long, with a polished surface, is generally used to roll the paper upon, and a wooden board with a handle at the back is required to press the layers of paper together after the paper has been rolled.

To roll a case.—Place the piece of paper on the slab, paste over the whole of the upper surface; then lay the former upon the paper close to the bottom edge, and parallel to it. Roll up tightly to the top, using as many slips of papers as is necessary for the thickness of the case. Press down the wooden board upon the case and former, rolling it forward, until the layers of paper adhere closely, and the case is of the proper guage. Slip the case off the former.

If required for a rocket, or other contracted case, it must then be choked with a strong piece of cord until the vent is reduced to the size of the spindle that will be used when the case is driven.

ROMAN CANDLES.

When the case has been properly finished, ram in a little dry clay, then put in a small quantity of grain powder, then a star, after which a ladle full of composition is to be put in and lightly rammed down. Repeat this operation with the powder, star, and composition till the case is filled, after which it must be primed, and capped.

The ladle used for this and all other cases ought to be two diameters and a half in length, and a little less than half a diameter in height, so as to admit of its entering the case.

Roman candles fired alone are generally placed upright in rows, but when used in connection with a fixed piece, they may be fired at any inclination, not exceeding 45°.

Signal rocket composition, with about 4 oz. of mealed powder to the proportions hereafter given, makes about the best composition for Roman candles.

The signal rocket stars are also the best for Roman candles; they ought to be just of such size as to drop readily to the bottom of the case.

CRACKERS.

The case is made of cartridge paper, the dimensions required being 15 inches by 3½ inches. First fold down one edge, about ¾ of an inch broad, then turn down the double edge about ¼ of an inch, and bend back the single edge over the double fold, so as to form within a channel, which is to be filled with mealed powder, not ground very fine; the powder is then to be covered by the folds on each side, and the whole is to be pressed by a flat ruler; and the part containing the powder is to be folded into the remainder of the paper, every fold being pressed down. The cracker is then doubled backwards, and forwards in folds about 2¼ inches, which are pressed quite close, and a piece of twine is passed twice round the middle across the folds, and the joinings secured by causing the twine to take a turn round the middle at each fold successively; one of the ends of the folds may be doubled short under, which will produce an extra report; the other must project a little beyond the rest for the purpose of being primed.

EARTHQUAKE, ARTIFICIAL.

Mix together twenty pounds of iron sand, and twenty pounds of sulphur: and after making it into a paste with water, bury it a little depth in the ground. In ten or twelve hours, if the weather be warm, the earth will swell up, and burst; flames will also issue out, scattering around a yellow and black dust.

GERBES.

Gerbes consist of strong cylindrical choked cases of thick paper, filled with brilliant composition, and sometimes with balls, or stars. Gerbes throw up into the air luminous and sparkling jets of fire; and when arranged in a circular manner, as the radii of a circle, they form what is called a fixed sun. The thickness of the cases for brilliant fire must be a fourth part of the diameter, and for Chinese fire a sixth part. The case is loaded on a nipple, having a point equal in length to the same diameter, and in thickness to a fourth part of it; but as it generally happens that the mouth of the jet becomes larger than is necessary for the effect of the fire, the case should be first charged by filling it to a height equal to a fourth part of the diameter, with clay, which must be rammed down. When clay has been thus used, care must be taken to clear it out at the top of the hollow left by the spindle. When the charge is completed with the composition, the case should be closed with about two drachms of powder, and then choked. The train, or match, must be of the same composition as that employed for loading, otherwise the jet would be subject to burst. Jets intended for representing sheets of fire ought not to be choked. They must be placed in a horizontal position, or inclining a little downwards.

Composition for Gerbes, or jets of fire.

JETS.		Saltpetre.		Mealed powder.		Sulphur.	Charcoal.	Iron sand, or filings.	
		lb.	oz.	lb.	oz.	oz.	oz.		oz.
·4 of an inch or less interior diameter . .	Chinese fire	1		1		8	2		
	White fire .	1			8	3	2	Sand, 1st order	8
·5 to 1 inch diameter . .	Brilliant fire			1				Filings . . .	5
	White fire .	1				8	2		
	Chinese fire	1	4			5	5	Sand, 3rd order	12
1·1 to 1·5 diameter . .		1	4			7	5	Mixed Sand .	12
				1	8		5		
		2		2			8		
Any case to ½ lb. . . .	Chinese fire		12	1	2	6	4	Iron borings .	10

The saltpetre, powder, and charcoal, are three times sifted through a hair sieve. The iron filings are preserved from the deterioration, which would result from the presence of sulphur, by coating them with marine glue. This is done by cutting up 2 oz. of marine glue into small pieces, and melting it in a pan with 1 lb. of iron filings.

They are then added to the other ingredients, and the whole mixed by hand, or with a brush.

The composition is put in by ladlesful; the first two ought to be of charcoal 2 oz., mealed powder 1 lb., and driven in with a mallet and drift, 15 blows to each ladleful of composition.

All mallets, and drifts used for fireworks should be made of boxwood.

IRON SAND, OR POUNDED IRON.

Having broken a cast-iron plate, or iron pot, to pieces, on an anvil, pulverize the fragments till the grains are not larger than radish seed, then sift them through six graduated sieves to separate the different sizes; and preserve these six different kinds in a very dry place, in closely-corked bottles. The grains which pass through the first or finest sieve, are called *Sand of the* 1*st order*, and those that pass through the second sieve, *Sand of the 2nd order*, &c. Cast-iron borings are well adapted for this purpose.

LEADERS, OR PIPES OF COMMUNICATION.

These are small tubes of paper, of lengths adapted to the distances to which they are to extend. The paper is cut into slips two or three inches broad, or sufficient to go four times round the formers, which are about one-fourth of an inch diameter. Brass wire formers are the best, and should be oiled to prevent the paper sticking. Quick match is inserted in these tubes, but must be made to go in easily. The quick match should project an inch beyond each end of the leader, and should be inserted into the mouths of the cases of the fireworks with a small quantity of mealed powder. The leaders must not be placed too near, or cross each other so as to touch, as it may happen that the fire from one may communicate to another, and destroy thereby the intended arrangements.

MARROONS.

Marroons are boxes containing from 1 to 6 ounces of powder. They are made either on a square, or round former, and the ends of the paper are pasted down, and well welded round with kitted twine worked over cross-ways. A hole is bored into the case, and a match inserted.

MEALING GUNPOWDER.

A small quantity of powder being placed on a table with a rim round it, is rubbed down with a scored wooden mealer until all the grains are broken, and it becomes sufficiently fine to pass through a lawn sieve. Or, it may be beaten in a strong leather bag with wooden mauls: or, ground in a revolving drum with copper balls; projecting ribs being constructed in the interior of the drum, and covered with leather.

PORTFIRES FOR ILLUMINATIONS; OR SPECKIE OF LANCES.

The cases are made of three or four rounds of demy paper, the last round being pasted; they are from two to five-eighths of an inch in diameter, and from two to six inches long; they are pinched close at one end, and left open at the other. In filling them, a small quantity of the composition must be put in at a time, ramming it lightly, so as not to break the case.

The composition should be inserted by means of a funnel and wire; the wire being moved up and down in the case admits a small quantity at a time through the neck of the funnel, and presses it gently down.

Brilliant, and diversified displays of fireworks may be readily exhibited by means of speckie of lances. Illuminated designs of figures, &c., are represented by affixing on a black board small cases filled with various coloured compositions, to which leaders must be attached. The cases are fastened on with glue, and red lead mixed together.

Compositions.

							White.		Yellow.		Blue.		Yellow.	
	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.
Saltpetre . . .	1		6		2		2	4		8	1	2	1	
Sulphur		8	2		3			8	1			4		8
Mealed powder .		6	1					4		12				10
Antimony, crude .			1		1			4						
Gum Succum . .										8				
Antimony, prepared												8		
Basket salt . . .														6

Stars, crosses, revolving suns, &c., being fixed on the wooden frame with the speckie, will form a brilliant display.

RAIN, GOLD, AND SILVER.

Fill small paper cases, the same as cases for lances, with the composition, and place upon the mouth of each some moist powder, both to keep in the composition, and to serve as a match. If the head of a rocket be loaded with these cases, or quills, a shower of fiery rain will be produced at the extreme range of the rocket.

Compositions.

Gold Rain.

1. Mealed powder, 12 oz.; saltpetre, 2 oz.; charcoal, 4 oz.
2. Saltpetre, 8 oz.; sulphur, 4 oz.; mealed powder, 12 oz.; charcoal, 5 oz.

Silver rain.

1. Saltpetre, 4 oz.; sulphur, mealed powder, and antimony, each 2 oz.; sal prunella, ½ oz.
2. Saltpetre, 8 oz.; sulphur, 2 oz.; charcoal, 4 oz.
3. Saltpetre, 1 lb.; antimony, 6 oz.; sulphur, 4 oz.
4. Saltpetre, 4 oz.; sulphur, 1 oz.; powder, 2 oz.; steel dust, ¾ oz.

ROCKETS, LINE.

Any rocket, which is not very large, may be made to run along an extended rope. For this purpose affix to the rocket an empty case, and introduce therein the rope which is to carry it, placing the head of the rocket towards that side to which it is intended to move. Two rockets with an empty case may be similarly used, and may be made to move in a retrograde direction by placing them with their heads reversed, and a leader to communicate from the head of the rocket to be first ignited to the tail of the second.

ROCKETS, SIGNAL.

Composition.

Pulverized saltpetre, 4 lb.; sublimed sulphur, 1 lb.; dogwood charcoal, 1 lb. 12 oz.

The charcoal is first pounded fine enough to pass through a wire sieve, 36 meshes to the inch. The saltpetre and sulphur are each separately passed through a fine hair sieve, then mixed well together with a copper slice, and passed three times through the hair sieve. The charcoal is then spread on a tray, and the saltpetre and sulphur sifted a fourth time on it, and the whole being carefully mixed with a hard brush, is afterwards passed four times through the wire sieve.

To each ladleful of composition, 25 blows are given for the pound, and 21 for the half-pound rocket.

Twenty-eight ladlesful of composition (7½ oz.) are required to complete the pound, and twenty-five (5 oz.) the half-pound rocket.

To prevent accidents in driving rockets, &c., the workman should keep his body erect, the drift being well cleaned after each ladleful; and while driving, it should be moved backward, and forward by a pair of holders.

Rockets are driven 3½ calibres hollow, 1 calibre solid, and ½ calibre with clay.

Moulds.

		Length.	Diameter.
1 Pounder	Exterior	14 inches	3·9
	Interior	10·5 „	1·7
½ Pounder	Exterior	11·6 „	2·3
	Interior	8·5 „	1·3

Spindles.

	Diameter.			
	Top.	Middle.	Bottom.	Length.
1 Pounder	·2	·35	·5	6·4
½ Pounder	·2	·3	·4	5·2

Drifts.

	Length.	Diameter.	Hollowed.	No.
1 Pounder	12·1 inches	1·1	6·5	1
	10 „	1·1	5·7	2
	7·3 „	1·1	2·5	3
	6·8 „	1·1	Solid	4
½ Pounder	9·3 „	·9	5·4	1
	7·1 „	·9	2·3	2
	4 „	·9	Solid	3

The rocket is primed with mealed powder, and spirits of wine.

When complete, the length of the pound rocket is 15½ inches; and the half-pound 12 inches; the weight of the pound rocket and stick is 1¾ lb.; and the half-pound, 13 oz.

Length of sticks for rockets.

1-Pounder rocket	8 feet.	Half-pounder	6 feet 4 inches.

Star compositions.

No. 1.

Saltpetre, pulverized	8 lb.	Isinglass, dissolved	3½ oz.
Sulphur, sublimated	2 lb.	Vinegar	1 quart.
Antimony, pounded	2 lb.	Spirits of wine	1 pint.

2. *White stars.* Mealed powder, 4 oz.; saltpetre, 12 oz.; sulphur vivum, 6 oz.; oil of spike, 2 oz.; camphor, 5 oz.

3. *Blue stars.* Mealed powder, 8 oz.; saltpetre, 4 oz.; sulphur, 2 oz.; spirits of wine, 2 oz.; oil of spike, 2 oz.

4. *Brilliant stars.* Saltpetre, 3½ oz.; sulphur, 1½ oz.; mealed powder, ¾ oz., worked up with spirits of wine.

5. *Common stars.* Saltpetre, 1 lb.; sulphur, 4 oz.; antimony, 4¾ oz.; isinglass, ½ oz.; camphor, ½ oz.; spirits of wine, ¾ oz.

6. *Tailed stars.* Mealed powder, 3 oz.; sulphur, 2 oz.; saltpetre, 1 oz.; charcoal, coarsely ground, ¾ oz.

7. *Drove stars.* Saltpetre, 1 lb.; antimony, 4 oz.; sulphur, 8 oz.

8. *Fixed pointed stars.* Saltpetre, 8½ oz.; sulphur, 2 oz.; antimony, 1 oz. 10 drs.

The dry ingredients are well mixed, and sifted through a hair sieve: the isinglass dissolved over a fire with vinegar, and the spirits of wine afterwards added, and with which the dry composition is thoroughly mixed. It is then formed on moulds, and a hole is left in the middle to assist its ignition. Thirty-six stars are put in a 1-pounder, and twenty-two in a half-pounder rocket.

A great variety of figures may be represented in the air by attaching to a large rocket several small rockets, or small cases filled with the composition; or serpents may be attached to the rocket by means of packthread.

SALTPETRE, PULVERIZED.

Sixteen pounds of refined lakepetre are put into a copper vessel, to which four quarts of water are added. It is placed over a charcoal fire to boil; as the water evaporates it is well stirred with copper-shod spatulas or paddles, occasionally taking it off the fire, until the evaporation ceases; and when brought to a fine powder it is sifted through a hair sieve, and spread on paper to cool.

To extract saltpetre from damaged gunpowder.

Dissolve the powder in warm water, filter the solution through fine linen bags, and then evaporate the water by boiling it, until the solution is of sufficient strength to crystallize.

SERPENTS, OR SQUIBS.

The case is made by rolling stout cartridge paper in slips of 6 or 8 inches in breadth three times round a former, and pasting down the last fold. The case, having been choked at one end, is filled about two-thirds with the composition, and a small piece of paper is inserted, over which powder is placed, and this end is secured with twine. At the other extremity, moist powder with touch-paper is inserted. To introduce the composition into the case, a funnel and wire are used, the wire being pressed down hard upon the composition.

Composition.

	1. lb.	oz.	2. lb.	oz.	3. lb.	oz.
Mealed powder	1	8	1	0	1	0
Charcoal		4		1		12
Sulphur		1		0		
Saltpetre		3		1¾		

SHELLS, OR AERIAL GLOBES.

These globes are made of wood, and their thickness is equal to about a twelfth part of their diameters. The usual charge is an ounce of powder for a shell of 4 lb. weight, and 2 ounces for a shell of 8 lb. They may be fired from any mortars that have not a chamber.

To form the shell.

Two wooden hemispheres (with a fuze hole) are joined firmly together, enclosing stars, squibs, rain, &c. A small quantity of powder is inserted to explode the shell, by means of a fuze.

SHOWERS OF FIRE, OR CASCADES.

Make a case ½ an inch in diameter, the thickness of paper being about ⅛th of an inch. Stop up one end with clay. Drive it with the composition firmly with a drift and mallet, a ladleful at a time. These cases must be fixed on a frame with leaders, to be fired simultaneously.

Compositions.

Chinese fire. Mealed powder, 1 lb.; saltpetre, 2 oz.; iron filings, very fine, 8 oz.; charcoal, very fine, 5 oz.

Ancient fire. Mealed powder, 1 lb.; charcoal, 2 oz.

Brilliant fire. Mealed powder, 1 lb.; iron filings, 4 oz.

The Chinese fire is the best of the above compositions.

The charcoal, and iron filings ought to pass through a 60 mesh sieve.

SPUR FIRE.

Compositions.

	1. lb.	oz.	2. lb.	oz.
Saltpetre	4	8	1	8
Sulphur	2			8
Lamp black	1	8		6

The saltpetre and sulphur must be first sifted together, and then put into a marble mortar with the lamp black. These ingredients must be thoroughly mixed with a wooden pestle. The composition, if rubbed too much, will be too fierce, and hardly show any stars; and on the contrary, when not mixed enough, will be too weak, and throw out an obscure smoke, and lumps of dross without any stars. This composition is generally rammed in 1, or 2 ounce cases, about five, or six inches long, but not driven very hard. Cases filled with spur fire may be used in rooms without any danger of setting fire to the furniture, &c., and some of them being placed round a transparent pyramid of paper, and fired in a large room, make a very pretty appearance.

SUNS, OR WHEELS, FIXED, AND MOVEABLE.

None of the pyrotechnic inventions can be applied with so much success in artificial fireworks, as suns, or wheels, of which there are two kinds, fixed, and revolving.

FIXED SUNS.

Construct a circular piece of wood, into the circumference of which screw 12 or 15 pieces in the form of radii, and to these attach jets of fire, the mouth of each of which must be towards the circumference of the frame; and leaders being affixed to all the jets, they will, when ignited, produce the appearance of a radiated sun. The wheel is fixed vertically. The jets may be arranged so as to cross each other in an angular manner, in which case a *star*, or *cross of Malta* will be formed. To produce a very brilliant effect, these suns may be made with several rows of jets.

REVOLVING SUNS.

Provide a wooden wheel of the requisite size, and bring it into perfect equilibrium around its centre, in order that the least effort may make it turn round. Attach to the circumference of it jets placed in the direction of the circumference; and affix leaders of match to communicate the fire from jet to jet, according as may be required. When fire is applied to one of the jets, the recoil will immediately cause the wheel to revolve, unless it should be too ponderous or large: therefore, when these suns are intended to be of a considerable size, that is, when they consist of twenty jets, fire must be communicated at the same time to the 1st, 6th, 11th, and 16th, from which it will proceed to the 2nd, 7th, 12th, and 17th, and so on. Four jets will thus make the wheel revolve rapidly. If two similar suns be placed one behind the other, and made to turn round in a contrary direction, they will produce a very brilliant cross fire.

For a sun 5 feet in diameter, the cases should be 8 oz., filled about 10 inches in length with composition.

Compositions.

Slow fire.

	oz.
Saltpetre	4
Sulphur	2
Mealed powder	1½

Dead fire.

	oz.
Saltpetre	1¼
Sulphur	¼
Lapis Calemanaris	¼
Antimony	⅛

Brilliant fire.

	lb.	oz.
Mealed powder	6	0
Saltpetre		8
Sulphur		2
Iron Sand		12

Illumination fire.

	lb.	oz.
Saltpetre	1	0
Sulphur		8
Mealed powder		6

Golden colour.

	lb.	oz.
Mealed powder	1	0
Charcoal, very good		2

Red Chinese fire.

	lb.	oz.
Mealed powder	1	0
Saltpetre	1	0
Charcoal		4
Sulphur		4
Iron sand, 2nd and 3rd order		14

White Chinese fire.

	lb.	oz.
Mealed powder	1	0
Saltpetre	1	0
Sulphur		8
Iron sand, 2nd & 3rd order		14

Grey colour.

	lb.	oz.
Mealed powder	1	0
Saltpetre		4
Sulphur		2
Charcoal		1¼

Four ounce cases will be required for wheels of 14, or 16 inches; if the wheels are larger, 8 oz., 1 lb., or even 2 lb. cases will be required.

The Chinese compositions are intended for cases of nine-tenths of an inch interior diameter, but they will be found to answer for cases as low as four ounces.

TOUCH PAPER.

Dissolve saltpetre in water; more or less of the saltpetre, according as the paper is to burn fast, or slow: then dip into the solution blue paper, which, when well saturated, take out, and dry for use. The touch-paper must be cut into slips, placed once round the mouth of the firework, and the end of the paper outside the case should be twisted to a point.

WHEELS, PIN, OR CATHERINE.

The pipe, or case is made on a long wire former, about three-sixteenths of an inch in diameter, into which the composition is poured through a funnel, and shaken down. The case is then rolled round a small circle of wood about one inch in diameter, and not more than half an inch thick, with a hole through the centre of it for a nail, or pin. One end of the case is to be pasted round the wood, and each half turn of it secured with sealing-wax, or a strip of paper pasted across the wheel. The end is then primed.

Composition.

Mealed powder, 12 oz.; saltpetre, 3 oz.; sulphur, 1½ oz.

Two ounces of iron sand, or camphor, may be added, but it keeps better without either.

COLOURED FIRES FOR ILLUMINATIONS.

To be laid in trains about an inch in breadth, and half an inch in depth. When lighted at one end, they will burn gradually to the other, illuminating the surrounding vicinity.

Compositions.

Purple.

	lb.	oz.
Chlorate of Potassa	5	8
Saltpetre	3	0
Sulphur	3	0
Oxide of Copper .	1	4
Black Sulphuret of Mercury .		8

Crimson.

	lb.	oz.
Nitrate of Strontia	7	0
Sulphur	2	0
Chlorate of Potassa		3
Charcoal (very fine)		2½

Green.

	lb.	oz.
Nitrate of Baryta	3	12
Sulphur . . .		10½
Arsenic . . .		8
Chlorate of Potassa		4
Charcoal (very fine)		1½

Note.—Before the chlorate of potassa is mixed, the other ingredients ought to be passed three times through a sieve. After which they should be spread out, and the chlorate of potassa sifted over them, when the whole will have to be passed once through a sieve.

PART XV.

MATHEMATICS.

Mathematics is the science which treats of all kinds of quantity whatever, that can be numbered, or measured.

Arithmetic is that part which treats of numbering.

Fractions treat of broken numbers, or parts of numbers.

Algebra is the art of computing by symbols.

In this science, quantities of all kinds are represented by the letters of the alphabet.

Geometry is the science relating to measurement. By the assistance of geometry, engineers, &c., conduct all their works, take the distances of places, and the measure of inaccessible objects, &c.

Characters, marks, or signs, which are used in arithmetic, and algebra, to denote several of the operations, and propositions:

$+$ *signifies* plus, or addition, $-$ minus, or subtraction,
$\times$,, multiplication, $\div$ division,
: : : : proportion, $=$ equality, $\surd$ square root,
$\sqrt[3]{}$ cube root, 4^2 *denotes that* 4 is to be squared.
4^3 *denotes that* 4 is to be cubed.

ARITHMETIC.

REDUCTION.

Reduction is the method of converting numbers from one name, or denomination to another: or the method of finding the value of a quantity in terms of some other higher, or lower quantity.

To reduce from a higher to a lower denomination.

Rule.—Multiply the given number by as many of the lower denomination as make one of the greater;* adding to the product as many of the lower denomination as are expressed in the given sum.

Example.—In £6 15*s.* 5*d.*, how many pence?

$$\begin{array}{rrl} \text{£.} & s. & d. \\ 6 & 15 & 5 \\ 20 & & \\ \hline 135 & & \\ 12 & & \\ \hline 1625 & \multicolumn{2}{l}{\textit{Answer.}} \\ \hline \end{array}$$

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* *Vide Tables of Weights, and Measures.*

To convert from a lower to a higher denomination.

Rule.—Divide the given number by as many of the lower denomination as are required to make one of the greater.* Should there be any remainder, it will be of the same denomination as the dividend.

Example. — Convert 1625 pence into pounds, shillings, and pence.

12) 1625 pence

20) 135 5

£6 15*s.* 5*d. Answer.*

* *Vide Tables* of Weights, and Measures.

THE RULE OF THREE, OR SIMPLE PROPORTION.

It is called the *Rule of Three* because three numbers are given to find a fourth. It is also called *Simple Proportion*, because the 1st term bears the same proportion to the 2nd, as the 3rd does to the 4th. Of the three given numbers, two of them are always of the same kind, or name, and are to be the 1st, and 2nd terms of the question; the 3rd number is always of the same name, or kind as the 4th, or answer sought; and in stating the question it is always to be made the 3rd term. If the answer will be *greater* than the 3rd term, place the least of the other two given quantities for the 1st term; but if the answer will be *less* than the 3rd term, put the greater of the two numbers, or quantities, for the 1st term.

Rule.—State the question according to the above directions, and multiply the 2nd and 3rd terms together, and divide this product by the 1st, for the 4th term, or answer sought.

If the 1st and 2nd terms are not of the same denomination, they must be reduced to it; and if the third term is a compound number it must be reduced to its lowest denomination before the multiplication, or division of the term takes place.

Note 1.—The operation may frequently be considerably abridged, by dividing the 1st and 2nd, or the 1st and 3rd terms, by any number which will exactly divide them, afterwards using the quotients, instead of the numbers themselves.*

Example.—If 2 tons of iron for ordnance cost £40, how many tons may be bought for £360?

As £40 : £360 : : 2 tons : 18 tons.

(Thus 360 × 2)÷40 = 18. The Answer.

* Or thus, 9 × 2 = 18. The Answer.

Note 2.—*A concise method of ascertaining the Annual amount of a daily sum of money.*

Rule.—Bring the daily sum into pence, and then add together as many pounds, half pounds, groats, and pence, as there are pence in the daily sum, for the amount required. For leap year, add the rate for one day.

Example.—Required the annual amount of 2*s.* 6*d.* per diem.

2*s.* 6*d.* = 30*d.*

30 pounds.
15 = 30 half pounds
10*s.* = 30 groats.
2*s.* 6*d.* = 30 pence.

Annual amount (365 days) £45 12*s.* 6*d.*

Note 3.—To find the amount of any number of days' pay, the daily rate (under twenty shillings) being given.

The price of any article being given, the value of any number may be ascertained in a similar manner.

Rule 1. When the rate (or price) is an even number, multiply the given number by half of the rate, doubling the first figure to the right hand for the shillings, the remainder of the product will be pounds.

Rule 2. When the price is an odd number, find for the greatest number as before, to which add one-twentieth of the given number for the odd shilling.

Example. Required the amount of 243 days' pay, at 4*s.* per diem.

$\frac{4}{2}=2$ 243
2

£48 12*s.* *Ans.*

Example. What is the price of 566 pairs of shoes, at 7*s.* per pair.

566 2/0)56/6
3
28 6
169 16*s.*
28 6

£198 2*s.* *Ans.*

FRACTIONS.

A fraction is a quantity which expresses a part, or parts of a unit, or integer. It is denoted by two numbers placed with a line between them.

A Simple fraction consists of two numbers, called the numerator, and denominator; thus, $\frac{3}{5}$ numerator, denominator.

The Denominator is placed below the numerator, and expresses the number of equal parts into which the integer is divided.

The Numerator expresses the number of parts of the broken unit, or integer; or shows how many of the parts of the unit are expressed by the fraction.

A Compound fraction is a fraction of a fraction, as $\frac{2}{3}$ of $\frac{4}{5}$.

A Mixed number consists of a whole number with a fraction annexed to it, as $4\frac{3}{5}$.

An Improper fraction has the numerator greater than the denominator, as $\frac{6}{5}$.

REDUCTION OF FRACTIONS

is bringing them from one denomination to another.

To reduce a fraction to its lowest terms.

Rule.—Divide the numerator, and the denominator, by any number that exactly divides them, and the quotients by any other number, till they can be no longer divided by any whole number, when the fraction will be in its lowest terms.

Example.—Reduce $\frac{4032}{6048}$ to its lowest terms.

$$\text{Thus, } \overset{4}{\frac{4032}{6048}}=\overset{12}{\frac{1008}{1512}}=\overset{6}{\frac{84}{126}}=\overset{7}{\frac{14}{21}}=\frac{2}{3}.\quad \textit{Answer.}$$

To reduce an improper fraction to a whole, or mixed number.

Rule.—Divide the numerator by the denominator, the quotient will be the whole number; and the remainder (if any) the numerator of the fraction, having the divisor for the denominator.

Example.—Reduce $\frac{114}{12}$ to a whole, or mixed number.

$$\begin{array}{l} 12)\underline{114} \\ \quad 9\tfrac{6}{12}\ \textit{Answer.} \end{array}$$

To reduce a mixed number to an improper fraction.

Rule. — Multiply the whole number by the denominator, and add the numerator to the product, under which place the given denominator.

Example.—Reduce $17\frac{5}{8}$ to an improper fraction.

$$\begin{array}{r} 17\tfrac{5}{8} \\ \underline{8} \\ \underline{141} \\ 8\ \textit{Answer.} \end{array}$$

To reduce a compound fraction to a simple fraction.

Rule.—Multiply all the numerators together for the numerator, and all the denominators for the denominator.

Example.—Reduce $\frac{3}{8}$ of $\frac{1}{6}$ of $\frac{1}{2}$ of 9 to a simple fraction.

$$\begin{array}{l} \text{Numerators} \\ \\ \text{Denominators} \end{array} \quad \frac{3\times1\times1\times9}{8\times6\times2\times1}\quad\frac{27}{96}=\frac{9}{32}\ \textit{Answer.}$$

To reduce fractions of different denominators to equivalent fractions, having a common denominator.

Rule.—Multiply each numerator by all the denominators except its own for the new numerators, and multiply all the denominators together for a common denominator.*

Example.—Reduce $\frac{3}{8}$, $\frac{2}{3}$, and $\frac{4}{5}$ to fractions having a common denominator.

---

* In reducing fractions to a common denominator, and in multiplication of fractions, the work may be considerably diminished by cancelling any figures, which are in all the multiples; or by dividing a figure in each of them by any figure which can divide all without any remainder.

$3 \times 3 \times 5 = 45$
$2 \times 8 \times 5 = 80$
$4 \times 8 \times 3 = 96$
$8 \times 3 \times 5 = 120$ *Answer*, $\frac{45}{120}$, $\frac{80}{120}$, and $\frac{96}{120}$.

ADDITION OF FRACTIONS.

Rule.—Bring compound fractions to simple fractions; reduce all the fractions to a common denominator, then add all the numerators together, and place their sum over the common denominator. When mixed numbers are given, find the sum of the fractions, to which add the whole numbers.

Example.—Add together $\frac{5}{6}$, $\frac{3}{4}$, and $6\frac{1}{2}$.

$5 \times 4 \times 2 = 40$
$3 \times 6 \times 2 = 36$ $\quad \frac{40}{48} + \frac{36}{48} + \frac{24}{48} + 6 = 8\frac{4}{48}$.
$1 \times 6 \times 4 = 24$ $\quad$ or, by cancelling, and dividing,*
$6 \times 4 \times 2 = 48$ $\quad \frac{10}{12} + \frac{9}{12} + \frac{6}{12} + 6 = 8\frac{1}{12}$. *Answer.*

SUBTRACTION OF FRACTIONS.

Rule.—Prepare the quantities, as in addition of fractions. Place the less quantity under the greater. Then, if possible, subtract the lower numerator from the upper; under the remainder write the common denominator, and, if there be whole numbers, find their difference as in simple subtraction. But if the lower numerator exceed the upper, subtract it from the common denominator, and to the remainder add the upper numerator; write the common denominator under this sum, and carry 1 to the whole number in the lower line.

Example.—From $54\frac{5}{6}$ or $54\frac{25}{30}$
Take $25\frac{5}{15}$ or $25\frac{10}{30}$

$29\frac{15}{30}$ or $29\frac{1}{2}$. *Answer.*

MULTIPLICATION OF FRACTIONS.

Rule.—Reduce mixed numbers to equivalent fractions; then multiply all the numerators together for a numerator, and all the denominators together for a denominator, which will give the product required.

Example.—Multiply $\frac{5}{6}$, $\frac{3}{8}$, and $2\frac{1}{2}$ together.
$\frac{5}{6} \times \frac{3}{8} \times (2\frac{1}{2}$ or$)\ \frac{5}{2} = \frac{75}{96}$ *Answer.*

DIVISION OF FRACTIONS.

Rule.—Prepare the fractions, as for multiplication; then divide the numerator by the numerator, and the denominator by the denominator, if they will exactly divide; but if they will not do so, then invert the terms of the divisor, and multiply the dividend by it, as in multiplication.

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* See Note, page 274.

Example.—Divide $\frac{9}{16}$ by $4\frac{1}{2}$.

$\frac{9}{16} \div (4\frac{1}{2}$ or) $\frac{9}{2} = \frac{1}{8}$ *Answer.*

RULE OF THREE IN FRACTIONS.

Rule.—State the terms, as directed in "Simple proportion;" reduce them (if necessary) to improper, or simple fractions, and the *two first* to the same denomination. Then multiply together the second and third terms, and the first with its parts inverted, as in division, for the answer.

Example.—If $4\frac{1}{5}$ cwt. of sugar cost £$19\frac{7}{8}$, how much may be bought for £$59\frac{5}{8}$?

As $19\frac{7}{8} : 59\frac{5}{8} :: 4\frac{1}{5}$

Or, $\frac{159}{8} : \frac{477}{8} :: \frac{21}{5} : 12\frac{3}{5}$ *Answer.*

$\frac{8}{159} \times \frac{477}{8} \times \frac{21}{5} = \frac{80136}{6360} = 12\frac{3}{5}$ cwt.

DECIMALS.

A decimal fraction is that which has for its denominator an unit (1), with as many ciphers annexed as the numerator has places; and it is usually expressed by setting down the numerator only, with a point before it, on the left hand. Thus, $\frac{5}{10}$ is ·5; $\frac{25}{100}$ is ·25; $\frac{25}{1000}$ is ·025; ciphers being *prefixed*, to make up as many places as are required by the ciphers in the denominator.

A mixed number is made up of a whole number with some decimal fraction, the one being separated from the other by a point, thus 3·25 is the same as $3\frac{25}{100}$ or $\frac{325}{100}$.

Ciphers on the right hand of decimals make no alteration in their value; for ·5, ·50, ·500 are decimals having all the same value, each being = $\frac{5}{10}$. But when they are placed on the left hand, they decrease the value in a tenfold proportion; thus, ·5 is $\frac{5}{10}$; but ·05 is $\frac{5}{100}$.

ADDITION OF DECIMALS.

Rule.—Set the numbers under each other, according to the value of their places, in which state the decimal separating points will all stand exactly under each other. Then beginning at the right hand, add up all the columns of numbers as in integers, and point off as many places for decimals as are in the greatest number of decimal places in any of the lines that are added; or place the point directly below all the other points.

Example.—Required the sum of 29·0146, 3146·5, 14·16, and 165.

```
   29·0146
 3146·5
   14·16
  165·
 ---------
Answer 3354·6746
```

SUBTRACTION OF DECIMALS.

Rule.—Place the numbers under each other according to the value of their places. Then, beginning at the right hand, subtract as in whole numbers, and point off the decimals, as in addition.

Example.—Subtract 4·90142 from 214·81.

214·81
4·90142

Answer 209·90858

MULTIPLICATION OF DECIMALS.

Rule.—Place the factors, and multiply them together, the same as if they were whole numbers. Then point off in the product just as many places of decimals as there are decimals in both the factors. But, if there be not so many figures in the product, prefix ciphers to supply the deficiency.*

Example.—Multiply 32·108 by 2·5.

32·108
2·5

160540
64216

80·2700 *Answer.*

DIVISION OF DECIMALS.

Rule.—Divide as in whole numbers, and point off in the quotient as many places for decimals as the decimal places in the dividend exceed those in the divisor. When the decimal places of the quotient are not so many as the above rule requires, the deficiency is to be supplied by prefixing ciphers. When there is a remainder after the division, or when the decimal places in the divisor are more than those in the dividend, then ciphers may be annexed to the dividend, and the quotient carried on as far as required.

Example.—Divide 234·7052 by 64·25.

64·25)234·7052(3·65 *Answer.*
19275

41955
38550

34052
32125

1927 *Remainder.*

---

* *To multiply decimals by* 1, *with any number of ciphers, as* 10, 100, &c.—This is done by only removing the decimal point so many places farther to the right hand, as there are ciphers in the multiplier, and subjoining ciphers, if need be.

REDUCTION OF DECIMALS.

To reduce a vulgar fraction to its equivalent decimal.

Rule.—Divide the numerator by the denominator, as in Division of Decimals, annexing ciphers to the numerator as far as necessary: and the quotient will be the decimal required.

Example.—Reduce $\frac{7}{24}$ to a decimal.

24 = 4 × 6. Then 4)7·

6)1·75

·291666, &c., *Answer.*

To find the value of a decimal, in terms of the inferior denominations.

Rule.—Multiply the decimal by the number of parts in the next lower denomination, and cut off as many places to the right hand for a remainder, as there are places in the given decimal. Multiply that remainder by the parts in the next lower denomination, again cutting off for another remainder as before. Proceed in the same manner through all the parts of the integer; then the several denominations, separated on the left hand, will make up the answer.

Example.—What is the value of ·775 pounds sterling?

·775
20

Shillings 15·500
12

Pence . 6·000 *Answer* 15*s.* 6*d.*

To convert integers, or decimals to equivalent decimals of higher denominations.

Rule.—Divide by the number of parts in the next higher denomination, continuing the operation to as many higher denominations as may be necessary.

When there are several numbers, all to be converted to the decimal of the highest—

Set the given numbers directly under each other for dividends, proceeding from the lowest to the highest; opposite to each dividend, on the left hand, place such a number for a divisor as will bring it to the next higher name. Begin at the uppermost, and perform all the divisions, placing the quotient of each division, as decimal parts, on the right hand of the dividend next below it; so shall the last quotient be the decimal required.

Example.—Convert 15*s.* 9$\frac{3}{4}$*d.* to the decimal of a pound sterling.

4 | 3·
12 | 9·75
20 | 15·8125
£ ·790625 *Answer.*

Example.—Convert 1 dwt. to the decimal of a pound, Troy weight.

20)1
12) ·05 oz.
·004166 lb., &c., *Answer.*

RULE OF THREE IN DECIMALS.

Rule.—Prepare the terms, by reducing the fractions to decimals; compound numbers to decimals of the higher denominations, or integers of the lower; also the first, and second terms to the same name. Then multiply, and divide, as in the Rule of Three, in whole numbers.

Example.—If $\frac{3}{8}$ of a yard of cloth cost £$\frac{2}{5}$, what will $\frac{5}{16}$ of a yard cost?

$\frac{3}{8}$ = ·375   yd. yd. £. s. d.
As ·375 : ·3125 :: 4 : ·333 &c. or 6 8
4
$\frac{2}{5}$ = ·4   ·375) ·12500 (·3333 &c.
·1125   20
$\frac{5}{16}$ = ·3215   1250*s.* 6·666 &c.
1125   12
Answer, 6*s.* 8*d.*   .125*d.* 7·999 &c. nearly 8*d.*

DUODECIMALS.

By Duodecimals, artificers, &c., compute the content of their works.

Rule.—Set down the two dimensions to be multiplied together one under the other, so that feet may stand under feet, inches under inches, &c.

Multiply each term in the multiplicand, beginning at the lowest, by the feet in the multiplier, and set the result of each straight under its corresponding term, observing to carry 1 for every 12, from the inches to the feet. In like manner multiply all the multiplicand by the inches, and parts of the multiplier, and set the result of each term one place removed to the right hand of those in the multiplicand: omitting, however, what is below parts of inches, only carrying to these the proper number of units from the lowest denominations. Or, instead of multiplying by the inches, take such part of the multiplicand as those are of a foot.

Then add the two lines together for the content required.

Example.—Multiply 14 feet 9 inches, by 4 feet 6 inches.

ft.	in.	
14	9	
4	6	
59	0	
7	4½	
66	4½	*Answer.*

TABLES OF WEIGHTS, AND MEASURES.

TROY WEIGHT.

24 grains	1 pennyweight.		
480	20	1 ounce.	
5760	240	12	1 pound.

AVOIRDUPOIS WEIGHT.

16 drams	1 ounce.				
256	16	1 pound.			
7168	448	28	1 quarter.		
28672	1792	112	4	1 hundred weight.	
573440	35840	2240	80	20	1 ton.

Note.—14 pounds = 1 stone; 2 stones = 1 quarter.

1 lb.	Avoirdupois weight	=	14 oz. 11 dwts. 15½ grs. Troy.
1 oz.	ditto	=	18 dwts. 5½ do.
1 dr.	ditto	=	27·34375 do.

APOTHECARIES' WEIGHT.

20 grains	1 scruple.			
60	3	1 dram.		
480	24	8	1 ounce.	
5760	288	96	12	1 pound.

WEIGHTS.

To find the weight, for tonnage.

Cattle—

Divide the number by 3, for weight in tons.

Sheep . . . Average 60 lb. each.

Divide by 33, for weight in tons.

Pigs . . . Average 80 lb.

Divide by 15, for tons.

Beer, or Ale—

Barrel	3¼ cwt.
Hogshead	5¼ cwt.

Oats . . . Sack . . . . 24 stone.

Divide quarters by 5, for tons.

Rum—

Divide gallons by 224, for tons.

Wine . . . Cask . . . . 12 cwt.

Rule for ascertaining the weight of Hay.

Measure the length and breadth of the stack; then take its height from the ground to the eaves, and add to this last one-third of the height from the eaves to the top: Multiply the length by the breadth, and the product by the height, all expressed in feet; divide the amount by 27, to find the cubic yards, which multiply by the number of stones supposed to be in a cubic yard (viz., in a stack of new hay, six stones; if the stack has stood a considerable time, eight stones; and if old hay, nine stones), and you have the weight in stones. For example, suppose a stack to be 60 feet in length, 30 in breadth, 12 in height from the ground to the eaves, and 9 (the third of which is three) from the eaves to the top; then 60 × 30 × 15 = 27000: 27000 ÷ 27 = 1000; and 1000 × 9 = 9000 stones of old hay.

LONG MEASURE.

12 inches	1 foot.				
36	3	1 yard.			
198	16½	5½	1 pole, perch, or rod.		
7920	660	220	40	1 furlong.	
63360	5280	1760	320	8	1 mile.

LAND MEASURE (*Length*).

7·92 inches	1 link.
100 links, or 22 yards	1 chain.
80 chains	1 mile.
69·121 miles	1 geographical degree.

LAND MEASURE (*Surface, or Superficial*).

62·7264 square inches	1 square link.
625 square links	1 square pole, or perch.
10000 square links	1 square chain.
2500 square links	1 square rood, or pole.
10 square chains	1 square acre.
100000 square links	1 square acre.

NAUTICAL MEASURE.

1 nautical mile	6082·66 feet.
3 miles	1 league.
20 leagues	1 degree.
360 degrees	the earth's circumference.

SQUARE MEASURE.

144 s. inches	1 s. foot.				
1296	9	1 s. yard.			
39204	272¼	30¼	1 s. pole.		
1568160	10890	1210	40	1 rood.	
6272640	43560	4840	160	4	1 acre.

CUBIC MEASURE (*Measure of solidity*).

1728 cubic inches . . 1 cubic foot.
27 cubic feet . . . 1 cubic yard.

Note.—A cubic foot is equal to 2200 cylindrical inches, or 3300 spherical inches, or 6600 conical inches.

Timber.

40 feet of round, and 50 feet of hewn timber make 1 *Ton*; 16 cubic feet make 1 *Foot* of wood: 8 feet of wood make 1 *Cord*.

Water.

Maximum density 42 deg. Fahrenheit.

1 cubic foot of water	6¼ imperial gallons.
1 cylindric foot do.	about 5 do.
1 cubic foot	weighs 62·5 lb. avoirdupois.
1 cylindric do.	do. 49·1
1 lineal do. (1 inch square)	do. ·434
12·2 imperial gallons	weigh 1 cwt.
224 do.	do. 1 ton.
1·8 cubic feet	do. 1 cwt.
35·84 do.	do. 1 ton.

MEASURES OF CAPACITY.

69⅓ cubic in.	2 pints	1 quart.				
277¼	8	4	1 gallon.			
554½	16	8	2	1 peck.		
2218⅓	64	32	8	4	1 bushel.	
10¼ cubic ft.	512	256	64	32	8	1 quarter.

FRENCH MEASURES.

	English cubic inches.
Millilitre	·06103
Centilitre	·61028
Decilitre	6·10279
Litre, or cubic decimetre	61·02791
Decalitre	610·27900
Hectolitre	6102·79000
Kylolitre	61027·90000
Myrialitre	610279·00000

1 litre is nearly 2⅛ wine pints.
1 kilolitre 1 tun 12¾ wine gallons.
1 stere, or cubic metre . 35·3171

	English feet.
Metre	3·281
,, French feet, 3·07844	
Millimetre	·03937
Centimetre	·39371
Decimetre	3·93708
Metre	39·37079
Decametre	393·70790
Hectometre	3937·07900
Kilometre	39370·79000
Myriametre	393707·90000

8 kilometres are nearly 5 miles.
1 inch is ·0254 metre,
100 feet are nearly 30·5 metres.

INVOLUTION.

Involution is the raising of powers from any given number, as a root.

A *Power* is a quantity produced by multiplying any given number, called the *Root*, a certain number of times continually by itself.

Thus, $2 \times 2 = 4$, the 2nd power, or square of 2, expressed thus, 2^2.

The index, or exponent of a power is the number denoting the height, or degree of that power.

Thus, 2 is the index of the 2nd power.

Powers that are to be raised, are usually denoted by placing the index above the root, or first power.

Thus, $2^2 = 4$, the 2nd power of 2.

Example.—What is the 2nd power of 45 ?

$45 \times 45 = 2025$ *Answer.*

EVOLUTION.

Evolution is the reverse of Involution, being the extracting, or finding the roots of any given powers, or numbers.

The Root of any number, or power, is such a number as being multiplied into itself a certain number of times, will produce that power.

Thus, 2 is the square root, or 2nd root of 4, because, $2^2 = 2 \times 2 = 4$; and 3 is the cube root, or third root of 27. But there are many numbers of which a proposed root can never be exactly found; by means of decimals, however, the root may be very nearly ascertained.

Any power of a given number, or root, may be found exactly by multiplying the number continually into itself.

Those roots which only approximate are called *Surd roots;* but those which can be found, quite exactly, are called *Rational roots.* Thus, the square root of 3 is a surd root, but the square root of 4 is a rational root, being equal to 2; also the cube root of 8 is rational, being equal to 2, but the cube root of 9 is surd, or irrational. Roots are sometimes denoted by writing the character $\sqrt{}$ before the power with the index of the root against it. Thus, the 3rd, or cube root of 20 is expressed by $\sqrt[3]{20}$. When the power is expressed by several numbers with the sign + or − between them, a line is drawn from the top of the sign over all the parts of it; thus the cube (or third) root of $45-12$ is $\sqrt[3]{45-12}$ or thus $\sqrt[3]{}(45-12)$.

TO EXTRACT THE SQUARE ROOT.

Rule.—Divide the given number into periods of two figures each, by setting a point over the place of units, and another over the place of hundreds, and so on over every second figure, both to the left hand in integers, and right hand in decimals. Find the greatest square in the first period on the left hand, and set its root on the right hand of the given number, after the manner of the quotient figure in division. Subtract the square thus found from the said period, and to the remainder annex the two figures of the next following period for a dividend. Double * the root above mentioned for a divisor, and find how often it is contained in the said dividend, exclusive of its right-hand figure; and set that quotient figure both in the quotient, and divisor. Multiply the whole augmented divisor by this last quotient figure, and subtract the product from the said dividend, bringing down to it the next period of the given number, for a new dividend. Repeat the same process over again—viz., find another new divisor, by doubling all the figures now found in the root; from which, and the last dividend find the next figure of the root as before; and so on through all the periods to the last.

To extract the square root of a fraction, or mixed number.

Reduce the fraction to a decimal, and extract its root.

Mixed numbers may be either reduced to improper fractions, and the root extracted; or the fraction may be reduced to a decimal, then joined to the integer, and the root of the whole extracted.

Example.—To find the square root of 29506624.

$$\begin{array}{r|l}
 & 2\dot{9}5\dot{0}6\dot{6}2\dot{4}\ (5432\ \text{The Root.} \\
 & 25 \\
\hline
104 & 450 \\
4 & 416 \\
\hline
1083 & 3466 \\
3 & 3249 \\
\hline
10862 & 21724 \\
2 & 21724
\end{array}$$

TO EXTRACT THE CUBE ROOT.

Rule 1.—By trials, or by the table of roots (*vide page* 286), take the nearest rational cube to the given number, whether it be greater, or less, and call it the assumed cube.

2.—Then (*by the Rule of Three*),

As the sum of the given number, and double the assumed cube, is to the sum of the assumed cube, and double the given number, so is the root of the assumed cube, to the root required, nearly.

---

* The best way of doubling the root, to form the new divisor, is by adding the last figure always to the last divisor, as appears in the following example.

After the figures belonging to the given number are all exhausted, the operation may be continued into decimals, by adding any number of periods of ciphers, two in each period.

3.—Or as the first sum,
is to the difference of the given, and assumed cube,
so is the assumed root,
to the difference of the roots, nearly.

4.—Again, by using, in like manner, the cube of the root last found as a new assumed cube, another root will be obtained still nearer. Repeat this operation as often as necessary, using always the cube of the last-found root, for the assumed root.

Example.—To find the cube root of 21035·8.

By trials it will be found *first*, that the root lies between 20, and 30; and, *secondly*, between 27, and 28. Taking, therefore, 27, its cube is 19683, which will be the assumed cube. Then by No. 2 of the Rule,

19683	21035·8
2	2
39366	42071·6
21035·8	19683·

As 60401·8 : 61754·6 : : 27 : 27·6047 the Root, nearly.

Again for a second operation, the cube of this root is 21035·318645155832, and the process by No. 3 of the Rule will be

21035·318645, &c.	
2	
42070·637290	21035·8
21035·8	21035·318645, &c.

As 63106·43729 : diff.·481355 : : 27·6047 :
: the diff. ·000210560

consequently the root required is 27·604910560

TABLE OF SQUARES, CUBES, AND ROOTS.

No.	Sqr.	Cube.	Sqr. root.	Cube root.	No.	Sqr.	Cube.	Sqr. root.	Cube root.
1	1	1	1·0000000	1·000000	51	2601	132651	7·1414284	3·708430
2	4	8	1·4142136	1·259921	52	2704	140608	7·2111026	3·732511
3	9	27	1·7320508	1·442250	53	2809	148877	7·2801099	3·756286
4	16	64	2·0000000	1·587401	54	2916	157464	7·3484692	3·779763
5	25	125	2·2360680	1·709976	55	3025	166375	7·4161985	3·802953
6	36	216	2·4494897	1·817121	56	3136	175616	7·4833148	3·825862
7	49	343	2·6457513	1·912933	57	3249	185193	7·5498344	3·848501
8	64	512	2·8284271	2·000000	58	3364	195112	7·6157731	3·870877
9	81	729	3·0000000	2·080084	59	3481	205379	7·6811457	3·892996
10	100	1000	3·1622777	2·154435	60	3600	216000	7·7459667	3·914867
11	121	1331	3·3166248	2·223980	61	3721	226981	7·8102497	3·936497
12	144	1728	3·4641016	2·289428	62	3844	238328	7·8740079	3·957892
13	169	2197	3·6055513	2·351335	63	3969	250047	7·9372539	3·979057
14	196	2744	3·7416574	2·410142	64	4096	262144	8·0000000	4·000000
15	225	3375	3·8729833	2·466212	65	4225	274625	8·0622577	4·020726
16	256	4096	4·0000000	2·519842	66	4356	287496	8·1240384	4·041240
17	289	4913	4·1231056	2·571282	67	4489	300763	8·1853528	4·061548
18	324	5832	4·2426407	2·620741	68	4624	314432	8·2462113	4·081656
19	361	6859	4·3588989	2·668402	69	4761	328509	8·3066239	4·101566
20	400	8000	4·4721360	2·714418	70	4900	343000	8·3666003	4·121285
21	441	9261	4·5825757	2·758923	71	5041	357911	8·4261498	4·140818
22	484	10648	4·6904158	2·802039	72	5184	373248	8·4852814	4·160168
23	529	12167	4·7958315	2·843867	73	5329	389017	8·5440037	4·179339
24	576	13824	4·8989795	2·884499	74	5476	405224	8·6023253	4·198336
25	625	15625	5·0000000	2·924018	75	5625	421875	8·6602540	4·217163
26	676	17576	5·0990195	2·962496	76	5776	438976	8·7177979	4·235824
27	729	19683	5·1961524	3·000000	77	5929	456533	8·7749644	4·254321
28	784	21952	5·2915026	3·036589	78	6084	474552	8·8317609	4·272659
29	841	24389	5·3851648	3·072317	79	6241	493039	8·8881944	4·290841
30	900	27000	5·4772256	3·107232	80	6400	512000	8·9442719	4·308870
31	961	29791	5·5677644	3·141381	81	6561	531441	9·0000000	4·326749
32	1024	32768	5·6568542	3·174802	82	6724	551368	9·0553851	4·344481
33	1089	35937	5·7445626	3·207534	83	6889	571787	9·1104336	4·362071
34	1156	39304	5·8309519	3·239612	84	7056	592704	9·1651514	4·379519
35	1225	42875	5·9160798	3·271066	85	7225	614125	9·2195445	4·396830
36	1296	46656	6·0000000	3·301927	86	7396	636056	9·2736185	4·414005
37	1369	50653	6·0827625	3·332222	87	7569	658503	9·3273791	4·431047
38	1444	54872	6·1644140	3·361975	88	7744	681472	9·3808315	4·447960
39	1521	59319	6·2449980	3·391211	89	7921	704969	9·4339811	4·464745
40	1600	64000	6·3245553	3·419952	90	8100	729000	9·4868330	4·481405
41	1681	68921	6·4031242	3·448217	91	8281	753571	9·5393920	4·497942
42	1764	74088	6·4807407	3·476027	92	8464	778688	9·5916630	4·514357
43	1849	79507	6·5574385	3·503398	93	8649	804357	9·6436508	4·530655
44	1936	85184	6·6332496	3·530348	94	8836	830584	9·6953597	4·546836
45	2025	91125	6·7082039	3·556893	95	9025	857375	9·7467943	4·562903
46	2116	97336	6·7823300	3·583048	96	9216	884736	9·7979590	4·578857
47	2209	103823	6·8556546	3·608826	97	9409	912673	9·8488578	4·594701
48	2304	110592	6·9282032	3·634241	98	9604	941192	9·8994949	4·610436
49	2401	117649	7·0000000	3·659306	99	9801	970299	9·9498744	4·626065
50	2500	125000	7·0170678	3·684031	100	10000	1000000	10·0000000	4·641589

PILING OF SHOT, AND SHELL.

Shot, and shells, are usually piled in horizontal courses, the base being either an equilateral triangle, a square, or a rectangle. The triangular, and square piles terminate each in a single ball, but the rectangular pile finishes in a row of balls.

To find the number of balls in a complete pile.

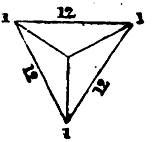
Rule.—Add the three parallel edges together; then the product of one-third of that sum, and of the number of balls in the triangular face, will be the number sought.

Note 1.—*The parallel edges* in a *rectangular pile* are the two rows in length at the base, and the upper ridge. In the *square pile* the same, except that the upper row is only a single ball. In the *triangular pile*, one side of the base, the single ball at top, and that at the back, are considered the parallel edges.

Note 2.—*The number of balls in the triangular face* is found by multiplying half the number in the breadth at the base, by the number in the breadth at the base *plus* 1.

Note 3.—In all piles, the breadth of the bottom is equal to the number of courses. In the oblong pile, the top row is one more than the difference between the length, and breadth of the bottom.

Example.—To find the shot in a triangular pile, the bottom row consisting of 12 shot.



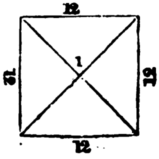
$$\text{Parallel edges}\begin{cases}12\\1\\1\end{cases}$$

$$3)\underline{14}$$
$$4\tfrac{2}{3}$$

$12 \div 2 = 6$
$12 + 1 = 13$

Triangular face 78
$4\tfrac{2}{3}$
312
52
Answer 364

Example.—To find the shot in a square pile, the bottom row consisting of 12 shot.

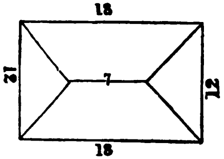


12
12
1
3)25
$8\tfrac{1}{3}$

$12 \div 2 = 6$
$12 + 1 = 13$
78
$8\tfrac{1}{3}$
624
26
Answer. 650

Example.—To find the shot in an oblong pile, whose base consists of 18 shot in length, and 12 in breadth.

$$\begin{array}{r}18-12=6\\ 1\\ \hline 7\\ \hline\end{array}\qquad\begin{array}{r}18\\ 18\\ 7\\ \hline 3)43\\ \hline 14\frac{1}{3}\\ \hline\end{array}\qquad\begin{array}{r}12\div2=\ 6\\ 12+1=13\\ \hline 78\\ 14\frac{1}{3}\\ \hline 312\\ 78\\ 26\\ \hline \textit{Answer}\ \ 1118\\ \hline\end{array}$$



The Number of balls in a Pile may be found by using the following formulæ, in which let the letter (L) denote the number in the bottom row, or the Length; and (B) the Breadth of the lowest course.

Triangular pile $\dfrac{L\times(L+1)\times(L+2)}{6}$

Square pile $\dfrac{L\times(L+1)\times(2L+1)}{6}$

Oblong pile $\dfrac{B\times(B+1)\times(3L+1-B)}{6}$

By referring to the following Table, the Number of Shot in any Pile (whose base does not exceed 21) may readily be ascertained.

Square pile.—Look for the number of shot in the base, in the first vertical column on the left hand, and also in the diagonal column; and at their angle of meeting will be found the content required.

Thus, 20 base gives 2870.

Triangular pile. —Look for the number in the base row in the diagonal column, and opposite to it will be found the content.

Thus, 18 base gives 1140.

Oblong pile.—Look for the number in the length of the base in the vertical column, and the breadth of the base in the diagonal column, and at their angle of meeting will be found the content required.

Thus, 17 length, and 12 breadth, gives 1040.

To find the number of balls in an Incomplete pile.—Compute the number in the pile considered as complete; also the number in the upper pile, or part wanting; and the difference between the two piles thus found will be the number in the frustrum, or incomplete pile.

Table for computing the Content of any Pile, whose base row does not exceed 21 balls.

1	2	4																				
2	5	3	10																			
3	8	14	4	20																		
4	11	20	30	5	35																	
5	14	26	40	55	6	56																
6	17	32	50	70	91	7	84															
7	20	38	60	85	112	140	8	120														
8	23	44	70	100	133	168	204	9	165													
9	26	50	80	115	154	196	240	285	10	220												
10	29	56	90	130	175	224	276	330	385	11	286											
11	32	62	100	145	196	252	312	375	440	506	12	364										
12	35	68	110	160	217	280	348	420	495	572	650	13	455									
13	38	74	120	175	238	308	384	465	550	638	728	819	14	560								
14	41	80	130	190	259	336	420	510	605	704	806	910	1015	15	680							
15	44	86	140	205	280	364	456	555	660	770	884	1001	1120	1240	16	816						
16	47	92	150	220	301	392	492	600	715	836	962	1092	1225	1360	1496	17	969					
17	50	98	160	235	322	420	528	645	770	902	1040	1183	1330	1480	1632	1785	18	1140				
18	53	104	170	250	343	448	564	690	825	968	1118	1274	1435	1600	1768	1938	2109	19	1330			
19	56	110	180	265	364	476	600	735	880	1034	1196	1365	1540	1720	1904	2091	2280	2470	20	1540		
20	59	116	190	280	385	504	636	780	935	1100	1274	1456	1645	1840	2040	2244	2451	2660	2870	21	1771	
21	62	122	200	295	406	532	672	825	990	1166	1352	1547	1750	1960	2176	2397	2622	2850	3080	3311	22	2024

CORDAGE.

Ropes, cables, and all other descriptions of cordage are distinguished by their circumference; thus a two-inch rope means a rope two inches in circumference.

1. *To find the weight of a rope.*

First method.—Multiply the length in fathoms by the square of the circumference, and divide the product by 480 for the weight in cwts.

Example.—Required the weight of 110 fathoms of 3-inch rope.

$3\times3\times110=990$, which divided by 480, gives 2 cwt. 7 lb. Weight required.

Second method.—Divide the square of the circumference by 4, the quotient will give the weight, in pounds, per fathom.

Example.—What is the weight of a 3-inch rope per fathom?

$3^2\div4=2\frac{1}{4}$ lb. Weight required.

2. *To find the strength of a rope, or the weight it will support.*

First method.—Square the circumference, and divide by 5, for the number of tons which it will bear suspended from it.*

Example.—What weight will 3-inch rope of the best description support?

$\dfrac{3\times3}{5}=\frac{9}{5}=1\frac{4}{5}$ ton, or 4030 lb. Weight required.

Second method.—Multiply the square of the circumference by 2, the product will give the *practical weight in cwts.* that may be lifted by it, or about half the breaking weight.

Example.—What number of cwts. may be lifted by a 3-inch rope?

$3^2\times2=18$ cwts. Weight required.

$$\left.\begin{array}{l}\textit{The strain, }\text{in pounds, }\textit{a rope will bear safely}=\text{girt}^2\times200\\ \quad ,, \qquad ,, \qquad \textit{a cable} \quad ,, \qquad ,, \;=\text{girt}^2\times120\end{array}\right\}\text{nearly.}$$

CHAINS.

1. *To find the weight of chains.*

The square of the diameter of the link, measured in eighths of inches, will give the weight of the chain, per fathom, in pounds.

Example.—What is the weight per fathom of a $\frac{3}{4}$-inch chain?

$\frac{3}{4}$-inch $=\frac{6}{8}$; $6^2=36$ lb. Weight per fathom.

Or, the weight per foot of the chain, multiplied by 24, will give the weight per fathom of the chain, *nearly*. A chain cable with a stay across the links will weigh about one-twelfth more than the foregoing examples.

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* *This rule is only applicable to the very best made new cordage. The circumference squared should be divided by 6 instead of 5 for the description of rope generally employed.*

2. *To find the weight that may be safely lifted by a chain.*

Divide the square of the diameter of the links, taken in eighths of an inch by 8, and the quotient will give the number of tons that may be lifted by the chain.

Example.—What number of tons will a chain made of ¾-inch iron carry with safety?

$\frac{3}{4}$-inch $= \frac{6}{8}$ $\quad 6^2 = 36 \quad \frac{36}{8} = 4\frac{1}{2}$ tons. Weight required.

The safe strain is equal to about 8 tons, per square inch, of the iron of which the chain is made.

The stay across the link of a chain increases its strength about one-sixth.

When the chain is of great length, a deduction, from the above rules, must be allowed for the weight of it.

IRON RODS.

1. *To find the weight of round iron rods.*

Divide the square of the diameter, in quarter inches, by 2, and the quotient will give the weight in pounds, per yard.

Example.—What is the weight of a yard of 1-inch round iron?

1 inch = 4 quarters $\quad 4^2 = 16 \quad \frac{16}{2} = 8$ lb. Weight required.

2. *To find the weight of square rods.*

The weight of round rods, of similar diameter, divided by ·7854 will give the weight of the square rods.

3. *To find the weight that may be sustained, or lifted by round iron rods.*

Find the weight in pounds, per yard; two-thirds of which will give the safe load, in tons.

A round iron rod of average quality of iron, one inch in diameter, will be torn asunder by 16 tons; it will be perceptibly damaged by half this strain, or 8 tons; its safe load will be one-third, or 5·33 tons.

4. *To reduce cubic feet of wrought iron into tons.*

The cubic feet multiplied by 1·5, divided by 7 = Tons.

One foot of 1 inch square wrought iron weighs 3·33 lb.
" " round " " 2·61 lb.

GIRDERS, weight of.

Wrought iron, weighing 480 *pounds per cubic foot.*

The sectional area, in inches, multiplied by the length in feet divided by 672 = weight in tons.

The sectional area in inches multiplied by 10 = weight of bar, in pounds, per yard.

For cast iron, deduct one twentieth.

TIMBER.

1. *To find the area, or superficial content of a plank.*

Multiply the length by the mean breadth.*

Example.—Required the content of a board whose length is 11 feet 2 inches, and breadth 1 foot 10 inches.

ft. in. ft. in. ft. in.
11 2 × 1 10 = 20 5. Content required.

2. *To find the solid content of squared, or four-sided timber.*

Multiply the mean breadth by the mean thickness, and the product by the length, for the content, nearly.

Note 1.—If the tree taper regularly from the one end to the other, either take the mean breadth, and thickness in the middle, or take the dimensions at the two ends, and half their sum will be the mean dimensions; which, multiplied as by the above rule, will give the content, nearly.

Note 2.—If the piece do not taper regularly, take several different dimensions, add them all together, and divide their sum by the number of them, for the mean dimensions.

Example.—Required the content of a piece of timber 16 feet long, and side of square 14 inches.

ft. in. ft. in. ft. ft. in.
1 2 × 1 2 × 16 = 21 9. Content required.

3. *To find the solidity of round, or unsquared timber.*

1. Multiply the square of the quarter girt (or the square of ¼ of the mean circumference), by the length, for the content.

Note.—When the tree is tapering, take the mean dimensions, either by girting it in the middle for the mean girt, or at the two ends, taking half the sum of the two; or by girting it in several places, then adding all the girts together, and dividing the sum by the number of them for the mean girt. But when the tree is very irregular, divide it into several lengths, and find the content of each part separately.

Example.—Required the content of a tree, whose mean girt is 3·15 feet, and length 14½ feet.

$$\frac{3\cdot15}{4} = \cdot7875 \quad \cdot7875 \times \cdot7875 = \cdot62015625 \quad 14\tfrac{1}{2} = 14\cdot5.$$

·62015 × 14·5 = 8·9922 feet of solid timber. The content required.

2. Find the mean area of a round tree, and multiply it by the length for the content.

4. *To find the weight of a tree.*

Find its content in feet, and multiply that by the specific gravity of the wood.

(*Vide* GRAVITY, *and Table of Specific Gravities. Pp.* 306, 307.)

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* When the board is tapering, add the breadths at the two ends together, and take half the sum for the mean breadth. *Or else*, take the mean breadth in the middle.

Example.—Required the weight of an elm-tree, whose mean girt is 5 feet, and length 60 feet.

$\frac{5}{4} = 1\cdot25 \qquad 1\cdot25 \times 1\cdot25 = 1\cdot5625.$
$1\cdot5625 \times 60 = 93\cdot75.$ Content in feet.

TONNAGE.

Table of Tonnage, and Weight of *One* of the following Carriages, Carts, Waggons, Gyns, &c., used in Land service.

				Tonnage		Weight.			
				tons.	ft.	cwt.	qrs.	lb.	
Carriages.	Travelling, complete.	For Iron Ordnance.	24 pounder	6	0	34	0	22	With bullock pole and chain, weighing 2 qr. 19 lb.
			8 inch	6	0	34	2	12	
			18 pounder	4	39	27	2	9	
			12 „ 21 cwt.	4	7	18	3	24	
			Howitzer 10 inch	6	17	39	0	9	
			Howitzer 8 „	5	37	33	2	0	Do. do. do.
		For Brass Ordnance.	12 pounder	5	33	22	0	10	
			9 „	5	1	20	2	14	
			6 „	4	21	17	3	5	
			Howitzer 32 pr.	5	29	23	3	13	
			Howitzer 24 „	5	6	21	0	17	
			Howitzer 12 „	4	21	18	3	14	
		Ammunition waggon		5	36	20	0	3	For all natures.
		Forge		5	38	19	1	0	
		Store waggon (without spare wheel)		5	11	18	1	10	
		Small arm ammunition waggon		4	36	14	2	16	
		Rocket	12 pounder	7	33	20	2	8	
		Rocket	6 „	5	17	20	1	20	
		Pontoon	Large	3	30	42	2	13	
		Pontoon	Small	..		22	2	5	
	Garrison, wood, common standing, for 32 pounder of 25 cwt.			1	8	8	0	7	
Capstan, crab				0	31	3	3	26	
Carts	Forge, cavalry			4	32	11	2	3	
	Hand			1	10	4	3	4	
	Hospital, conveyance			3	16	10	2	20	
	Sling			3	38	16	1	17	
	Store			3	16	9	1	0	
	French			1	32	5	2	13	
Drugs	Large			2	7	17	1	24	
	Small			0	29	5	0	4	
Gyns, Triangle	Large			1	23	9	2	22	
	Small			1	2	7	3	3	
Platform	Madras	For 32 pounder garrison carriage		0	26	6	0	12	Fir.
		For traversing carriage with tail-piece		1	23	14	2	0	Teak.
	Mortar, Alderson's pattern			0	30	8	1	4	
Portable forge, and pack saddle, in wooden case				0	17	2	1	3	
Waggons	Flanders			5	0	16	1	25	
	Platform			8	16	21	3	18	
	Sling			8	11	31	3	26	
Waggons, hospital, Mr. Holmes' pattern	Large			9	10	21	0	0	
	Small			6	30	18	0	4	

The calculation of tonnage for baggage, stores, &c., is by measurement: *a Ton*, consisting of 40 cubic feet; but metals, and very heavy articles are estimated by actual weight, without reference to bulk.

To ascertain the tonnage of sailing Vessels, the hold being clear.

Rule.—Divide the length of the upper deck, between the afterpart of the stem, and the forepart of the sternpost, into six equal parts.

Depths.—At the foremost, the middle, and the aftermost of those points of division, measure in feet, and decimal parts of a foot; the depth from the under side of the upper deck to the ceiling at the limber strake. In the case of a break in the upper deck, the depths are to be measured from a line stretched in a continuation of the deck.

Breadths.—Divide each of those three depths into five equal parts, and measure the inside breadths at the following points—viz., at one-fifth, and at four-fifths from the upper deck of the foremost, and aftermost depths, and at two-fifths, and four-fifths from the upper deck of the midship depth.

Length.—At half the midship depth measure the length of the vessel from the afterpart of the stem to the forepart of the sternpost; then to twice the midship depth add the foremost, and the aftermost depths for the sum of the depths; add together the upper, and lower breadths at the foremost division, three times the upper breadth, and the lower breadth at the midship division, and the upper, and twice the lower breadth at the after division, for the sum of the breadths: then multiply the sum of the depths by the sum of the breadths, and this product by the length, and divide the final product by 3500, which will give the number of tons for register.

If the vessel have a poop, or half deck, or a break in the upper deck, measure the inside mean length, breadth, and height of such part thereof as may be included within the bulk-head; multiply these three measurements together, and dividing the product by 92·4, the quotient will be the number of tons to be added to the result as above found.

In order to ascertain the tonnage of open vessels, the depths are to be measured from the upper edge of the upper strake.

To ascertain the tonnage of Steam-vessels.

Rule.—In addition to the foregoing rules, when applied for the purpose of ascertaining the tonnage of any ship or vessel propelled by steam, the tonnage due to the cubical content of the engine-room must be deducted from the total tonnage of the vessel, as determined by either of the rules aforesaid, and the remainder will be the true register tonnage of the said ship or vessel.

To determine the tonnage due to the cubical content of the Engine-room.

Rule.—Measure the inside length of the engine-room in feet and decimal parts of a foot, from the foremost to the aftermost bulk-head, then multiply the said length by the depth of the ship or vessel at the midship division as aforesaid, and the product by the inside breadth of the same division at two-fifths of the depth from the deck, taken aforesaid, and divide the last product by 92·4, and the quotient will be the tonnage due to the cubical content of the engine-room.

To ascertain the tonnage of Vessels when laden.

Rule.—Measure, *first*, the length on the upper deck between the afterpart of the stem, and the forepart of the stern-post; *secondly*, the inside breadth on the under side of the upper deck, at the middle point of the length; and, *thirdly*, the depth from the under side of the upper deck down the pump-well to the sink; multiply these three dimensions together, and divide the product by 130, and the quotient will be the amount of the register tonnage of such ships.

MECHANICS.

Mechanics is the science of forces, and the effects they produce when applied to machines in the motion of bodies.

Machine, or engine, is any mechanical instrument contrived to move bodies.

Equilibrium is an equality of action, or force, between two or more powers, or weights, acting against each other, by which they destroy each other's effects, and remain at rest.

The centre of motion is the fixed point about which a body moves.

The axis of motion is the fixed line about which it moves.

The centre of gravity is a certain point on which a body (being freely suspended) will rest in any position.

The whole momentum, or quantity of force of a moving body, is the result of the quantity of matter multiplied by the velocity with which it is moved.

THE MECHANICAL POWERS.

Power is compounded of the weight, or expansive force of a moving body multiplied into its velocity.

The power of a body, which weighs 40 lb., and moves with the velocity of 50 feet in a second, is the same as that of another body which weighs 80 lb., and moves with the velocity of 25 feet in a second: for the products of the respective weights, and velocities are the same.

$$40 \times 50 = 2000; \text{ and } 80 \times 25 = 2000.$$

Power cannot be increased by mechanical means.

Power is applied to mechanical purposes—

1. By the lever;
2. By the wheel, and axle;
3. By the pulley;
4. By the inclined plane;
5. By the wedge;
6. By the screw;

which are the simple elements of all machines.

The whole theory of these elements consists simply in causing the weight, which is to be raised, to pass through a greater or a less space than the power which raises it; for, as power is compounded of the weight, or mass of a moving body, multiplied into its velocity, a weight passing through a certain space may be made to raise, through a less space, a weight heavier than itself.

THE LEVER.

The lever is the most simple of all machines, being only a straight bar of iron, wood, &c., supported on, and moveable round a prop, called the *fulcrum.*

Case 1.—When the fulcrum of the lever is between the power, and the weight.

Rule.—Divide the weight to be raised by the power to be applied; the quotient will give the difference of leverage necessary to support the weight in equilibrium. Hence, a small addition either of leverage, or weight, will cause the power to preponderate.

Example 1.—A ball weighing 3 tons is to be raised by 4 men, who can exert a force of 12 cwt.: required the proportionate length of lever?

$$3 \text{ tons} = 60 \text{ cwt.}; \text{ and } \tfrac{60}{12} = 5.$$

In this example, the proportionate lengths of the lever to maintain the weight in equilibrium, are as 5 to 1. If, therefore, an additional pound be added to the power, the power side of the lever will preponderate, and the weight will be raised. But, although the ball is raised by a force of only one-fifth of its weight, no power is gained, for the weight passes through only one-fifth of the space. The products, therefore, arising from the multiplication of the respective weights, and velocities are the same.

Example 2.—A weight of 1 ton is to be raised with a lever 8 feet in length, by a man who can exert, for a short time, a force of rather more than 4 cwt.; required at what part of the lever the fulcrum must be placed?

$\frac{20 \text{ cwt.}}{4 \text{ cwt.}} = 5$; that is, the weight is to the power as 5 to 1, therefore, $\frac{8}{5 \times 1} = 1$ foot and a third, from the weight.

Example 3.—A weight of 40 lb. is placed 1 foot from the fulcrum of a lever; required the power to raise the same, when the length of the lever on the other side of the fulcrum is 5 feet?

$$\frac{40 \times 1}{5} = 8 \text{ lb. } \textit{Ans.}$$

Case 2.—*When the fulcrum is at one extremity of the lever, and the power at the other.*

Rule.—As the distance between the power, and the fulcrum is to the distance between the weight, and the fulcrum, so is the effect to the power.

Example 1.—Required the power necessary to raise 120 lb., when the weight is placed 6 feet from the power, and 2 feet from the fulcrum?

As 8 : 2 :: 120 : 30 lb. *Ans.*

Example 2.—A beam, 20 feet in length, and supported at both ends, bears a weight of 2 tons at the distance of eight feet from one end; required the weight on each support?

$\frac{40 \text{ cwt.} \times 8 \text{ feet}}{20 \text{ feet}} = 16$ cwt. on the support that is furthest from the weight; and $\frac{40 \times 12}{20 \text{ feet}} = 24$ cwt. on the support nearest to the weight.

Case 3.—*When the weight to be raised is at one end of the lever, the fulcrum at the other, and the power is applied between them.*

Rule.—As the distance between the power, and the fulcrum, is to the length of the lever, so is the weight, to the power.

Example.—The length of the lever being 8 feet, and the weight at its extremity 60 lb., required the power to be applied 6 feet from the fulcrum to raise it?

As 6 : 8 :: 60 : 80 lb. *Ans.*

Velocity is gained at the expense of power by the lever, and wheel, and axle.

Note 1.—When two men are carrying a load on a pole between them, the strongest man should have the weight placed nearer to him than the other man.

Note 2.—*To carry guns, &c.*—If the burden can be carried by four men; after having made it fast to the middle of a large lever, fix the extremities of this lever on two shorter levers, and place a man at each of the points, C, D, E, F. *Vide plate, Mechanics, Fig.* 1. In *Fig.* 2, the weight is equally divided between eight men, and in *Fig.* 3, between sixteen men.

THE WHEEL, AND AXLE.

The advantage gained is in proportion as the circumference of the wheel exceeds that of the axle; therefore, the larger the wheel, and the smaller the axle, the stronger is the power of this machine, but then the weight will rise proportionally slower. A winch may be used instead of a wheel, for in turning the winch the hand will describe a circle, and there is no difference in the result, whether an entire wheel be turned, or a single spoke which the winch as a lever represents.

Rule.—As the radius of the wheel is to the radius of the axle, so is the effect, to the power.

Example.—A weight of 50 lb. is exerted on the periphery of a wheel, whose radius is 10 feet; required the weight raised at the extremity of a cord wound round the axle, the radius being 20 inches.

$$\frac{50 \text{ lb.} \times 10 \text{ feet} \times 12 \text{ inches}}{20 \text{ inches}} = 300 \text{ lb. } \textit{Ans.}$$

THE PULLEY.

The pulley consists of a grooved wheel, called *a sheave*, moveable on an axis, or gudgeon, and enclosed in a frame, or case, called a *block*. By passing a cord over the pulley, a man will be enabled *to draw up* a weight equal to that which his own body supplies in pulling downwards.

By combining a number of pulleys, as many assistants are obtained as there are wheels: thus, two pulleys will have double the power of one, because half the weight is sustained by the frame to which one end of the cord is attached; but then it requires *double the time* to do the work. As the *friction of the pulley* is very great, particular attention must be paid that all the turns or kinks of a rope be taken out, before it is made use of, and it should enter easily into the grooves of the sheaves.

Rule.—Divide the weight to be raised by twice the number of pulleys in the lower block; the quotient will give the power necessary to raise the weight.

Example.—What power is required to raise 600 lb., when the lower block contains six pulleys?

$$\frac{600}{6 \times 2} = 50 \text{ lb. } \textit{Ans.}$$

TACKLES.

Tackles are named according to the number of blocks employed; and the arrangement, and size of gear. Small tackles are usually called *Jiggers;* larger ones, *Bartons;* still larger, *Luffs:* a heavy tackle, or combination of such is *a Purchase.*

The fall is the rope of which the tackle is composed; that end of it which is fixed to the block is called *the standing part*, or *end;* the other, which is pulled, or hauled on by the men, is called *the running part*, or *end;* and the parts which pass from one block to the other are called the *returns of the fall.*

In all operations with tackles, the following directions should be attended to:—

1st. Make fastenings stronger than appears *actually* necessary.

2nd. Examine the straps, and hooks of the blocks carefully.

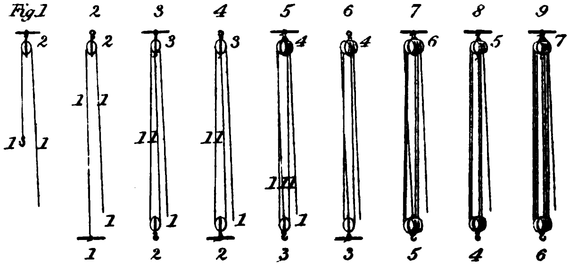
3rd. Consider whether the cordage is new, half-worn, or almost worn out.

4th. Attend to the seizings of the clinches, the sheet bends, the *proper* stoppering of the fall, the belaying the fall with two half hitches.

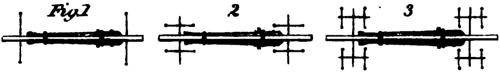
5th. Be very distrustful of selvages applied on smooth worn rope.

MECHANICS.

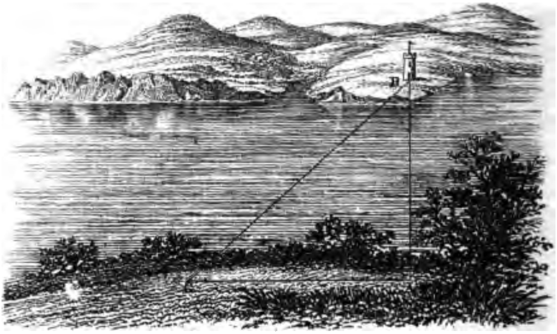
System of Pullies



To carry Guns &c



HEIGHTS AND DISTANCES.



6th. Do not allow ropes to be struck, or trampled on, when the weight is suspended.

7th. The men should *stand as safe* as the proper performance of the various duties will permit.

8th. In pulling a rope, the men ought to place themselves in a right line, and haul together. The most advantageous position for pulling is down a slope, or in a descending position.

COMBINATION OF PULLEYS.

A leading block is a fixed pulley, which alters the direction of the power, but does not increase it: Power = Weight. On account of friction the power must exceed the weight a little, in order to raise it.

Vide plate, Mechanics, Fig. 1.

A whip is one moveable pulley, which increases the power without altering the direction.

Power = $\frac{1}{2}$ weight (or 2 to 1).—*Vide Fig.* 2.

A whip upon whip will afford the same purchase as a tackle having a single and double block, and with much less friction.

A gun tackle consists of two single blocks with fall fixed to the one, then rove through the other, and then through the first. Power = $\frac{1}{2}$ weight (or 2 to 1): or Power = $\frac{1}{3}$ weight (or 3 to 1). *Vide Fig.* 3, *and* 4.

Two double blocks are generally used for very heavy guns.

A luff tackle, or half watch tackle, consists of one double and one single block: the fall is fixed to the single, then rove through first sheave of the double, then through sheave of single, and lastly through second sheave of double block. Power = $\frac{1}{3}$ weight (3 to 1): or Power = $\frac{1}{4}$ weight (4 to 1). *Vide Fig.* 5, *and* 6.

A runner tackle is the same as a luff tackle, applied to the end of a large rope, called a runner, which is rove through a single block attached to a fixed point, or to a body that is to be moved, or raised; the standing end of the runner being secured to another point.

Power is either 6 to 1, or 7 to 1, or 8 to 1.

A gyn tackle consists of one triple and one double block: the fall is fixed to the double, then rove through first sheave of triple, then through first sheave of double, then through second sheave of triple, then through second sheave of double, and lastly through third sheave of triple block.

Power = $\frac{1}{5}$ weight (5 to 1); or Power = $\frac{1}{6}$ weight (6 to 1). *Vide Fig.* 7.

If the moveable block of a tackle be strapped with a tail, it is called a *tail*, or *jigger block*: and the tackle a *tail*, or *jigger tackle*: a block with a hook strapped to it, and attached to a selvage, answers the same purpose.

Two double blocks, with fall fixed to one of them, and then rove through the sheaves of both blocks, will either give Power = $\frac{1}{4}$ weight (4 to 1): or Power = $\frac{1}{5}$ weight (5 to 1). *Fig.* 8.

Two triple blocks, with fall fixed to one of them, then rove through sheaves of both blocks, will either give power = $\frac{1}{6}$ weight (6 to 1): or Power = $\frac{1}{7}$ weight (7 to 1). *Fig.* 9.

In the system of pulleys (*vide plate, Mechanics*) the Power is shown at the hooks of the moveable blocks, which are to be applied to the bodies, or weights, requiring to be moved, or raised. The strain is also shown at the fixed blocks.

In Fig. 3, there are *three parts of the rope engaged* in supporting the weight—*viz., the parts marked* 1, 1, 1. Each of them, hence, sustains *one-third* of it, and the fall of the rope to which the power is to be attached requires the Power = 1, if weight = 3. The same principle of calculation is applicable to all systems of pulleys having one fixed block, any number of moveable wheels, and a single rope over all the wheels. Hence, in such a system of pulleys, gravity being applied, there will be an equilibrium, when the weight is as many times the power as there are portions of the rope employed in sustaining the weight. *For example,* in a system consisting of six moveable sheaves, the same rope going over them all, there will be 12 portions of the rope engaged; and to produce an equilibrium the power must be equivalent to $\frac{1}{12}$ the weight, no allowance being made for friction.

From the foregoing observations, and by referring to the plate, it will be seen that *each tackle has two applications,* differing in power one from the other; *for example,* if the double block of a luff tackle is fixed to a weight to be moved, and the single block to a picket, or other fastening, *Fig.* 6, then, if *one man* haul on the fall, the power of *four men* will be applied to the weight (4 to 1), and the power of *three men* to the picket; but if the double block be fixed to the picket, *Fig.* 5, and the single block to the weight, then the force of only *three men* will be applied to the weight (3 to 1), and a power of *four men* to the picket, or fastening.

When the moveable block of one tackle is fixed to the fall of another tackle, their respective powers are to be multiplied into each other for the power of the combination: thus, if one luff tackle is fixed to the fall of another luff tackle (the double blocks of both tackles being moveable), the power will be $4 \times 4 = 16$ (16 to 1): in this, the men haul through 16 feet to move the weight one foot; therefore if the combination be increased until the men haul through 100 feet to move the weight one foot, then the power would be 100 to 1.

The foregoing powers are, however, only true in theory, and are, therefore, called *theoretical powers:* for owing to the great friction of the pulleys, the stiffness of the ropes, &c., the actual *practical powers* are far less; so much so, that with a combination giving a power of 48 to 1, a 24-pr. (2½ tons weight) suspended, can scarcely overhaul the fall, the friction being so very great.

THE INCLINED PLANE.

The inclined plane forms simply a gradual and sloping instead of a sudden and perpendicular ascent, by which heavy bodies may be raised to certain heights. The power necessary for raising a weight depends on the difference between the length of the plane and the height to be ascended. If the height be one-third of the length, then one pound will lift three pounds. The force with which a rolling body descends on an inclined plane is to the force of its absolute gravity, as the height of the plane is to its length.

Parbuckling a gun on skids unites the advantage of one moveable pulley with that of the inclined plane.

Rule.—As the length of the plane is to its height, so is the weight to the power.

Example.—Required the power necessary to raise 540 lb. up an inclined plane, five feet long, and two feet high.

As 5 : 2 : : 540 : 216 lb. *Ans.*

THE WEDGE.

The wedge may be considered as two equally inclined planes joined together at their bases. It has a great advantage over all the other powers, arising from the force of percussion, or blow, with which the back is struck; which is a force incomparably greater than any dead weight, or pressure, such as is employed in other machines. The largest masses of timber may by this means be riven, and vessels of war, weighing many thousand tons, are lifted from their supports by the power of a few men, exerted by blows of mallets on wedges inserted for that purpose.

The power of the wedge increases in proportion as its angle is acute. In tools intended for cutting wood the angle is commonly about 30°; for iron from 50° to 60°; and for brass from 80° to 90°.

Case 1.—*When two bodies are forced from one another, by means of a wedge, in a direction parallel to its back.*

Rule.—As the length of the wedge is to half its back, or head, so is the resistance, to the power.

Example.—The breadth of the back, or head of the wedge, being 3 inches, and the length of either of its inclined sides 10 inches, required the power necessary to separate two substances, with a force of 150 lb.

As 10 : $1\frac{1}{2}$: : 150 : $22\frac{1}{2}$ lb. *Ans.*

Case 2.—*When only one of the bodies is moveable.*

Rule.—As the length of the wedge, is to its back, or head, so is the resistance, to the power.

Example.—The breadth, length, and force, the same as in the last example.

As 10 : 3 : : 150 : 45 lb. *Ans.*

THE SCREW.

The screw is a spiral thread or groove cut round a cylinder, and everywhere making the same angle with the length of it. The force of a power applied to turn a screw round is to the force with which it presses upward, or downward, setting aside the friction, as the distance between two threads is to the circumference where the power is applied; or the advantage gained is as much as the circumference of a circle described by the handle of the winch exceeds the interval, or distance, between the spirals of the screw. Hence the force of any machine turned by a screw can readily be computed; for instance, in a press driven by a screw, whose threads are each a quarter of an inch asunder, and with a handle, to turn the screw, four feet long; then, if the natural force of a man, by which he can lift, pull, or draw, be 150 lb., and it is required to determine with what force the screw will press when the man turns the handle with his whole force; the diameter of the handle (*power*) being 4 feet, or 48 inches, its circumference is 48×3·1416, or 150⅘ nearly; and the distance of the threads being one-fourth of an inch, therefore the power is to the pressure as 1 to (150⅘×4)=603⅕, but the power is equal to 150 lb., therefore as 1 : 603⅕ : : 150 : 90480, and consequently the pressure is equal to a weight of 90480 lb. independent of friction.

COMPOUND MACHINES.

Though each of the mechanical powers is capable of overcoming the greatest possible resistance in theory, yet in practice, if used singly for producing very great effects, they would frequently be so unwieldy and unmanageable as to render it impossible to apply them. For this reason it is generally found more advantageous to combine them together, by which means the power is more easily applied, and many other advantages are obtained. In all the mechanical powers, and their combinations, and in all machines, simple as well as compound, *what is gained in power is lost in time or velocity;* and *vice versâ*, or in other words, the product of the power, and the space through which it moves, is equal to the product of the weight, and the space through which it moves in the same plane. Suppose that a man, by means of a fixed pulley, raises a beam to the top of a house in two minutes, it is clear that he will be able to raise six beams in twelve minutes; but by means of a tackle with three lower pulleys, he will raise the six beams at once with the same ease as he before raised one, but then he will be six times as long about it, that is, twelve minutes: thus the work is performed in the same time whether the mechanical power is used, or not. But the convenience gained by the power is very great; for if the six beams are joined in one, they may be raised by the tackle, though it would be impossible to move them by the unassisted strength of one man. No real gain of force is obtained by mechanical contrivances: on the contrary, from friction and other causes, force is always lost; but by machines a more convenient direction can be given to the moving power, and so modify its energy as to obtain effects which it could not otherwise produce.

FRICTION.

Friction arises from the irregularities of the surfaces which move upon one another. The surfaces of bodies of the same nature are moved with more facility over each other than those of a dissimilar nature. In proportion as the surfaces which are to be moved upon one another are rough, a greater force is requisite to produce motion. The same surfaces when under a greater pressure, are subject to still further friction. A double pressure doubles the amount of friction, a treble pressure trebles, and so on in nearly the same proportion. When surfaces are moving along each other in the direction of their grains, the friction is greater than when the direction of the grains is at right angles. Friction is little influenced by the velocity with which bodies move upon one another. Friction may be diminished in various ways, as will appear by the result of the following experiment with a block of square stone weighing 1080 lb.:—

	lb.
1. In order to drag this stone along the floor of a quarry roughly chiselled, it required a force equal to	758
2. Over a floor of planks, ditto	652
3. Placed on a platform of wood, and dragged over a floor of planks	606
4. After soaping the two surfaces of wood, which slide over each other	182
5. Placed on rollers of three inches diameter, and moved along the floor of the quarry	34
6. To drag it on these rollers over a wooden floor	28
7. Mounted on a wooden platform, and the same rollers placed between the platform, and a plank floor	22

One of the most remarkable instances of the application of rollers is the transport of the rock which now serves as the pedestal of the equestrian statue of Peter the Great at St. Petersburg. This rock is a single block of granite weighing 1217 tons. A railway was formed, consisting of two lines of timber, furnished with hard metal grooves; similar, and corresponding metal grooves were fixed to the under side of the sledge, or frame, on which the stone was laid, and between these grooves were placed spheres of hard brass, about six inches in diameter. On these spheres the frame with its enormous load was easily moved by sixty men working at capstans with triple purchase blocks.

UNGUENTS.

Mr. G. Rennie found, from a mean of experiments, with different unguents, on axles in motion, and under different pressures, that, with the unguent tallow under a pressure of from 1 to 5 cwt., the friction did not exceed $\frac{1}{39}$th of the whole pressure; when soft soap was applied, it became $\frac{1}{31}$th; and with the softer unguents applied, such as oil, hogs' lard, &c., the ratio of the friction to the pressure increased; but with the harder unguents as soft soap, tallow, and anti-attrition composition, the friction considerably diminished; consequently, to render an unguent of proper efficiency; the nature of the unguent must be measured by the pressure, or weight, tending to force the surfaces together.

TRANSVERSE STRENGTH OF MATERIALS.

When a beam, of any material, is loaded, the surface in contact with the load is *compressed*, and the opposite surface *extended;* and there is a line between these, which is neither compressed, nor extended, called *the neutral line.*

If the depth of a beam be doubled, the breadth, and length between supports remaining the same, *its strength will be increased four times.*

If its breadth be doubled, the other dimensions being as above, *its strength will be doubled.*

By increasing the distance between the supports of any beam, its strength is decreased in the same ratio; twice the distance between the supports will weaken the beam one-half; half the distance between the supports will enable it to bear twice the load.*

The same beam will bear twice the load, if, instead of being concentrated in the middle, it be equally distributed over the whole length of the beam.

If the load on a beam be placed near to one of the supports, instead of in the middle, its effect will decrease in the ratio of its proximity to the support.

Let S s represent the beam, W the load or weight in the middle, w the weight near s; then the load which the beam will carry at the point where w is placed will be found by the following proportion:—

As S w × w s : S W × W s : : W : w.

A beam, fixed at one end, and loaded at the other, will bear half the weight of one of the same length supported at each end.

If the end of a beam, instead of being only supported, be *fixed,* its strength will be in the proportion of 3 to 2.

From the foregoing results it will be seen that the strength of a rectangular beam varies, as the breadth multiplied by the depth squared, divided by the length, $\frac{b \times d^2}{l}$; and if the breaking weight of any material, 1 inch square, and 1 foot long, be found, it will represent a *constant multiplier* for the above equation.

Thus the breaking weight of a beam of Riga fir, 1 inch square, and 1 foot long (*vide following* TABLE), is ·164 of a ton; and to find the breaking weight of a beam of any other dimensions, the rule is simply $W = \frac{b\,d^2}{l} \times \cdot 164.$

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* *To strengthen a beam, &c. which is required to support a great weight over a cavity, or ditch.*—Place a prop, or short skid, under the centre of the beam, and pass a strong rope, or chain, over the beam lengthways, and under the skid, hauling it very tight, and making fast.

Example.—What will be the breaking weight of a beam of Riga fir, 8 inches broad, 12 inches deep, and 20 feet long?

$$\frac{8 \times 12^2}{20} = 57 \cdot 6 \quad 57 \cdot 6 \times \cdot 164 = 9 \cdot 44 \text{ tons, breaking weight.}$$

Table of constants, for beams of different materials, being the breaking weights of such beams, 1 inch square, and 1 foot long.

Riga fir . . .	·164 of a ton.	English oak . .	·248 of a ton.
Red pine . . .	·199 „	Canadian do. .	·261 „
Pitch pine . . .	·242 „	Dantzic do. .	·219 „
Beech	·231 „	Teak	·366 „
Elm	·150 „	Cast iron, mean .	1·000 „
Ash	·301 „	Wrought do. .	1·083 „

From the foregoing rules

$$\begin{cases} \text{Length} = \dfrac{b\,d^2}{W} \times \text{constant.} \\[2ex] \text{Breadth} = \dfrac{l\,W}{d^2} \times \text{constant.} \\[2ex] \text{Depth} = \sqrt{\dfrac{l\,W}{b}} \times \text{constant.} \end{cases}$$

The practical weight that a beam will carry *with safety*, permanently, should only be taken at one-fourth of the above computations.

Note.—Result of experiments made by Mr. Arman, ship-builder, at Bourdeaux, to ascertain the strength of mahogany, as compared with French oak, and teak.

A piece of each kind of wood, about four inches square, was placed across the machine used for proving chain cables, and a piece of chain was attached to a ring fixed in the centre of it. A strain being laid on, the oak broke under a force of 1,800 kilogrammes (about 3,960 lb.); the teak with that of 3,300 (about 7,260 lb.); and the Honduras mahogany of 3,400 (about 7,480 lb.). The oak and teak appeared as if crushed, but without a complete disjunction of the fibres; the mahogany showed long splinters, indicating a much longer grain or fibre than the others.

ADHESION OF NAILS, AND SCREWS.

The percussive force required to drive the common sixpenny nail (73 to the pound) to the depth of an inch and a half into deal, with a weight of six pounds and a quarter, is four blows, or strokes, falling freely the space of one foot; and *the steady pressure* to produce the same effect is four hundred pounds. A *sixpenny nail* driven into dry elm to the depth of one inch across the grain requires a force of 327 pounds to extract it; and the same nail, driven into the same wood endways, or longitudinally, can be extracted with a force of 257 pounds.

To extract a sixpenny nail from a depth of one inch out of dry oak requires 507 pounds, and out of dry beech 667 pounds. A sixpenny nail driven two inches into dry oak would require a steady force of more than half a ton to extract it.

A common screw of one-fifth of an inch diameter has an adhesive force of about three times that of a sixpenny nail.

GRAVITY.

Gravity is downward pressure, or weight, being the natural tendency of all bodies towards the centre of the earth. (*Vide Gravity*, MOTION, FORCES. *Page* 309.)

Absolute gravity denotes the whole force with which a body tends downwards, as when the body is in empty space.

Specific gravity denotes the relative or comparative gravity of any body, in respect to that of another body of equal bulk, or magnitude.

Centre of gravity is that point in a body, or system of bodies, on which, if rested, or suspended, the whole would remain in a state of equilibrium about that point.

The centre of gravity of a circle, regular polygon, prism, cylinder, or sphere, is in its centre.

The centre of gravity of a triangle is found by bisecting any two of its sides, and drawing lines from the points of bisection to the opposite angles; the intersection of these lines will be the centre of gravity.

Force of gravity, or *gravitation*, is an accelerated velocity, which bodies acquire in falling freely from a state of rest.

1. The space through which a body will fall in feet, in any given time equals the product of the square of the time multiplied by 16·0833.

Example.—Required the space a falling body will pass through in five seconds?

$$16\cdot0833\times25=412\cdot0825 \text{ feet,}$$

2. The velocity in feet, which a body in descending freely will acquire in a given time, equals the product of the time in seconds multiplied by 32·1666.

Example.—What is the velocity acquired at the end of seven seconds?

$$32\cdot1666\times7=225\cdot1662 \text{ feet.}$$

3. The velocity in feet per second that a body will acquire, in falling through a given space, equals the square root of the product of the time multiplied by 64·3333.

Example.—The space through which a body has fallen is 201 feet; required its velocity at the end of the fall?

$$\sqrt{64\cdot3333\times201}=\sqrt{12931}=1137 \text{ feet.}$$

SPECIFIC GRAVITIES OF SEVERAL SOLID, AND FLUID BODIES.

Air,* in a mean state	1·232	Brick	2000
Brass, cast . . .	8000	Coal*	1250

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* 3 inch cube full of air floats 1 lb. in water.
3 inch cube of water weighs 1 lb. in air.
1 cubic foot of water weighs 64 lb. in air.
1 ditto coal ditto 80 − 64 = 16 in water.
1 ditto sand ditto 95 − 64 = 31 in water.

A suit of clothes and a pair of boots, which weigh 7 lb. in air, when well saturated with water, only weigh in water 1 lb.

Copper	9000
Cork	240
Clay	2160
Earth, common	1984
Flint	2570
Gold, standard	18888
Gun metal	8784
Gunpowder—solid	1745
,, loose	868
Granite	3000
Iron, cast	7425
Lead	11325
Pitch	1150
Sand*	1520
Silver, standard	10535
Steel	7850
Stone, common	2520
Tin	7320
Water, rain	1000
* sea	1030
Wood—alder	800
ash, the trunk	845
beech	852
elm, and larch	540
fir, Riga, & maple	750
pine, pitch & red	660
oak	950
walnut	671

As a cubic foot of water weighs 1000 ounces avoirdupois, the numbers, in the above Table, express not only the specific gravities of the several bodies, but also the weight of a cubic foot of each, in avoirdupois ounces; and therefore, by proportion, the weight of any other quantity, or the quantity of any other weight may be found.

To find the Magnitude of any body from its weight.

As the tabular specific gravity of the body
is to its weight, in avoirdupois ounces;
so is one cubic foot (or 1728 cubic inches)
to its content in feet, or inches, respectively.

To find the Weight of a body, from its magnitude.

As one cubic foot (1728 cubic inches)
is to the content of the body;
so is its tabular specific gravity
to the weight of the body.

To find the Specific gravity of a body.

1.—*When the body is heavier than water.*

Weigh it both in water, and out of water, and take the difference:

Then,—As the weight lost in water
is to the whole, or absolute weight;
so is the specific gravity of water
to the specific gravity of the body.

2.—*When the body is lighter than water,* so that it will not sink, annex to it another body heavier than water, so that the mass compounded of the two may sink together. Weigh the denser body, and the compound mass separately, both in water, and out of it; then find how much each loses in water, by subtracting its weight in water from its weight in air; and subtract the less of these remainders from the greater.

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* See note, page 306.

Then,—As the last remainder
is to the weight of the light body in air;
so is the specific gravity of water
to the specific gravity of the body.

3.—*For a Fluid of any sort.*

Take a piece of a body of known specific gravity, weigh it both in, and out of the fluid, finding the loss of weight by taking the difference of the two:—

Then,—As the whole, or absolute weight
is to the loss of weight;
so is the specific gravity of the solid
to the specific gravity of the fluid.

To find the Quantities of two ingredients in a given compound.

Take the three differences of every pair of the three specific gravities, namely, the specific gravities of the compound, and each ingredient, and multiply each specific gravity by the difference of the other two:

Then,—As the greatest product
is to the whole weight of the compound;
so is each of the other two products
to the weights of the two ingredients.

To find the Diameter of any small sphere, or globule, whose specific gravity is given (or can be found in the Table) and weight known.

Divide its weight in grains by the number expressing its specific gravity; extract the cube root of this quotient, and multiply it by 1·9612 for the diameter.

WEIGHT OF A CUBIC FOOT OF THE FOLLOWING MATERIALS, *in pounds.*

Ash	49	Gravel	120
Beech	43	Granite	166
Birch	49	Brick, common	98
Box	60	Chalk	145
Cork	15	Coal, Newcastle	78
Elm	36	Antimony	418
Fir	30	Brass, cast	525
Mahogany, Spanish	50	Copper	538
Pine, red	41	Gold, pure	1203
Teak	41	Iron, cast, variable	444
Walnut	41	Lead	717
Coke	46	Silver, standard	644
Clay	125	Tin	455
Earth, loose	95		

By means of the foregoing table, the weight of any quantity of the materials specified (in cubic feet) may readily be found.

MOTION, FORCES, &c.

Body is the mass, or quantity of matter in any material substance, and it is always proportional to its weight, or gravity, whatever its figure may be.

Density is the proportional weight, or quantity of matter in any body.

Velocity, or celerity, is an affection of motion by which a body passes over a certain space in a certain time.

Momentum, or quantity of motion, is the power, or force, in moving bodies.

Force is a power exerted on a body to move it, or to stop it. If the force act constantly, it is a *permanent force,* like pressure, or the force of gravity; but if it act instantaneously, or for an imperceptibly short time, it is called *impulse,* or *percussion,* like the smart blow of a hammer.

A motive, or moving force, is the power of an agent to produce motion.

Accelerative, or retardative force, is that which affects the velocity only, or it is that by which the velocity is accelerated, or retarded.

The change, or alteration of motion by any external force, is always proportional to that force, and in the direction of the right line in which it acts.

If a body be projected in free space, either parallel to the horizon, or in an oblique direction, by the force of gunpowder, or any other impulse: it will, by this motion, in conjunction with the action of gravity, describe the curve line of a parabola.

A parabola is the section formed by cutting a cone, with a plane, parallel to the side of the cone.

Gravity (*vide page* 306) is a force of such a nature that all bodies, whether light, or heavy, fall perpendicularly through equal spaces in the same time, abstracting the resistance of the air; as lead, and a feather; which, in an exhausted receiver, fall from the top to the bottom in the same time. The velocities acquired by descending, are in the exact proportion of the times of descent, and the spaces descended are proportional to the squares of the times, and, therefore, to the squares of the velocities. Hence, then, it follows that the weights, or gravities of bodies near the surface of the earth are proportional to the quantities of matter contained in them; and that the spaces, times, and velocities generated by gravity, have the relations contained in the three general proportions before laid down.

A body in the latitude of London falls nearly $16\frac{1}{12}$ feet in the first second of time, and consequently, at the end of that time, it has acquired a velocity double, or of $32\frac{1}{6}$ feet.

The times being as the velocities, and the spaces as the squares of either; therefore,

if the times be as the Nos.

1, 2, 3, 4, 5, 6, 7, 8, 9, 10;

the velocities will also be as

1, 2, 3, 4, 5, 6, 7, 8, 9, 10;

and the spaces as their squares

1, 4, 9, 16, 25, 36, 49, 64, 81, 100;

and the spaces for each time,

1, 3, 5, 7, 9, 11, 13, 15, 17, 19.

Namely, as the series of the odd numbers, which are the differences of the squares denoting the whole spaces. So that if the first series of natural numbers be seconds of time,

namely, the times in seconds . .	1	2	3	4	&c.
the velocities in feet will be . .	$32\frac{1}{6}$	$64\frac{1}{3}$	$96\frac{1}{2}$	$128\frac{2}{3}$,	&c.
the spaces in the whole times . .	$16\frac{1}{12}$	$64\frac{1}{3}$	$144\frac{3}{4}$	$257\frac{1}{3}$,	&c.
and the space for each second . .	$16\frac{1}{12}$	$48\frac{1}{4}$	$80\frac{5}{12}$	$112\frac{7}{12}$,	&c.

of which spaces the common difference is $32\frac{1}{6}$ feet, the natural, and obvious measure of the force of gravity.

Thus, a body falling from a state of rest acquires a velocity to pass through 9 spaces in the fifth second of time; 7 in the fourth; 5 in the third; 3 in the second; and 1 in the first. Thus it is $9 + 7 + 5 + 3 + 1 = 25$, which shows that the whole spaces passed through in 5 seconds equal the square of 5.

The momentum, or force, of a body falling through the atmosphere is the mass, or weight, multiplied by the square root of the height it has fallen through, multiplied by 8·021.

Suppose a weight of 10 tons to be raised 9 feet, and to drop thence suddenly on a bridge; the momentum is $10 \times (3 \times 8\cdot021) = 240\cdot63$ tons. That is, a weight of 10 tons, so falling, would exert as great a strain to break down the bridge, as the pressure of 240·63 tons of dead weight.

Thus, a one-ounce ball falling from a height of 400 feet, would strike the earth with a momentum of

$$\overset{\text{oz.}}{1} \times (\overset{\text{feet.}}{20} \times 8\cdot021) = \overset{\text{oz.}}{160\cdot42} = \overset{\text{lb.}}{10\cdot026}.$$

By experiments to ascertain the effect of Carnot's vertical fire, it was found that 4-oz. balls only penetrated $\frac{1}{20}$ of an inch into deal board, and from 2 to 3 inches into meadow ground.

Amplitude signifies the range of a projectile, or the right line upon the ground, subtending the curvilinear path in which it moves.

The time of flight of different shot, and shells is equal to the time a heavy body takes to descend freely from the highest point described by the curve of the projectile.

To find the Time of descent:

Divide the given height, or altitude, by $16\frac{1}{12}$, and the square root of the quotient will be the time required. Thus, if the altitude is 1200 feet, and the time of descent is required,

$1200 \div 16\frac{1}{12} = 74\cdot61$, the square root of which is 8·637, the time required.

When a body is projected vertically *downwards* with a given velocity, the space described is equal to the time multiplied by the velocity, together with the product of $16\frac{1}{12}$ by the square of the time; but, if the body is projected *upwards*, the latter product must be subtracted from the former.

PRACTICAL GEOMETRY.

DEFINITIONS.*

A line is perpendicular to another when it inclines not more on the one side than on the other, the angles on both sides being equal.

Parallel lines are those which have no inclination to each other, being everywhere equi-distant, however far produced, or extended.

An angle is the inclination, or opening of two lines, which meet in a point called the *vertex, or angular point:* and the two lines are called the *legs, or sides* of the angle.

The measure of an angle is estimated by the number of degrees contained in the arc between its two legs.

A rectilinear angle has its legs, or sides, *right*, or straight lines.

A curvilinear angle has its legs *curves*.

A right angle is formed by one line perpendicular to another; the measure of which is an arc of 90°.

An acute angle is less than a right angle, or than 90°.

An obtuse angle is greater than a right angle.

An oblique angle may be either acute, or obtuse.

The circumference, or periphery of a circle is the curved line which bounds it, being everywhere equally distant from the *centre*. The circumference is supposed to be divided into 360 degrees (marked thus °); each degree into 60 minutes, each minute (′) into 60 seconds (″).

An arc is any part of the circumference of a circle.

A chord, or subtense, is a right line joining the extremities of an arc.

The radius of a circle is a right line drawn from the centre to the circumference.

The diameter of a circle is a right line drawn through the centre, and terminated by the circumference.

A semi-circle (180°) is that part of a circle which is contained between the diameter, and half the circumference.

A quadrant is the fourth part of a circle, being contained between two radii, and an arc of 90°.

A segment is that part of a circle which is cut off by a chord.

A sector is that part of a circle contained between two radii, and an arc.

A secant is a line which cuts a circle, lying partly within, and partly without it.

A tangent is a line which touches a circle, or curve, without cutting it.

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* *Vide also Definitions*—TRIGONOMETRY, page 335.

The point of contact is where a tangent touches an arc.

Triangles are figures having three sides, and three angles.

An equilateral triangle has its three sides equal.

An isosceles triangle has only two equal sides.

A scalene triangle has all its sides unequal.

A rectangular, or right-angled triangle has one of its angles a right one, or 90°; and the square of the side opposite the right angle is equal to the sum of the squares of the sides containing that angle; hence a triangle, having its sides proportional to the numbers 3, 4, 5, will be right-angled.

The hypothenuse is the side opposite the right angle in a rectangular triangle.

An obtuse-angled triangle has one of its angles obtuse.

An acute-angled triangle has all its angles acute.

The three angles of any triangle, taken together, are equal to two right angles, or 180°.

The difference of the squares of two sides of a triangle is equal to the product of their sum, and difference.

The sides of a triangle are proportional to the sines of their opposite angles.

Quadrangles, or quadrilaterals, are plane figures bounded by four right lines.

A square is a quadrilateral having all its sides equal, and all its angles right angles. The *diagonal of a square* is equal to the square root of twice the square of its sides: and *the side of the square* is equal to the square root of half the square of its diagonal.

The diagonal is a right line drawn across a quadrilateral figure, from one angle to another. The sum of the squares of the two diagonals of every parallelogram is equal to the sum of the squares of the four sides.

A parallelogram is a quadrilateral, whose opposite sides are parallel.

A rectangle is a parallelogram having four right angles.

A rhomboid is an oblique-angled parallelogram.

A rhombus, or lozenge, is a quadrilateral, whose sides are all equal, but its angles oblique.

A trapezium is a quadrilateral, which has none of its sides parallel to each other.

A trapezoid is a quadrilateral, which has only two of its sides parallel.

Polygons are plane figures bounded by more than four sides.

A regular polygon has all its sides, and angles equal.

The perimeter of a figure is the sum of all its sides.

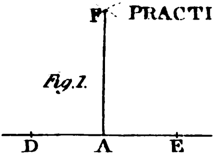
To bisect—is to divide into two equal parts.

To trisect—is to divide into three equal parts.

To inscribe—is to draw one figure within another, so that all the angles of the inner figure touch either the angles, sides, or planes of the external figure.

To circumscribe—is to draw a figure round another, so that either

PRACTICAL GEOMETRY.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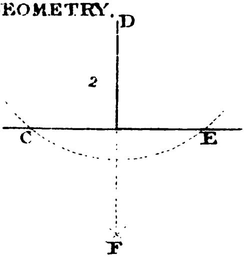
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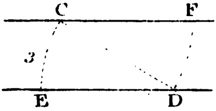
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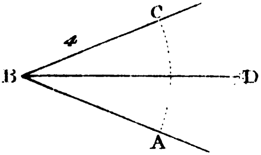
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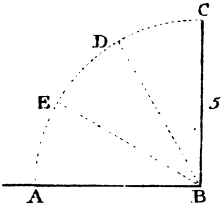
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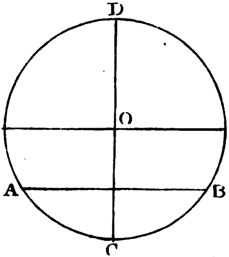
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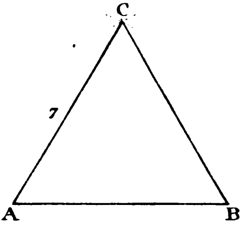
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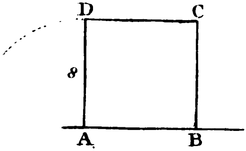
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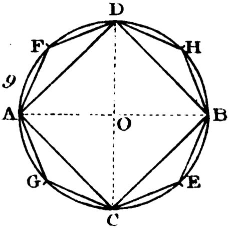
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the angles, sides, or planes of the circumscribing figure touch all the angles of the figure within it.

LINES, ANGLES, AND FIGURES.

To divide a given right line into two equal parts.

From the extremities of the line as centres, and with any opening in the compasses, greater than half the given line, as a radius, describe arcs intersecting each other above, and below the given line. A line being drawn through these intersections will divide the given line into two equal parts.

An arc of a circle is bisected in the same manner.

To erect a perpendicular.

From the point A set off any length 4 times to C: from A as a centre with 3 of those parts describe an arc at B, and from C with 5 of them cut the arc at B. Draw A B, which will be the perpendicular required. Any equimultiples of these numbers, 3, 4, 5, may be used for erecting a perpendicular. *Plate* 2, HEIGHTS AND DISTANCES, and PRACTICAL GEOMETRY, *Fig.* ½.

To erect a perpendicular.

Set off on each side of the point A, any two equal distances, A D, A E. From D, and E as centres, and with any radius greater than half D E, describe two arcs intersecting each other in F. Through A, and F draw the line A F, and it will be the perpendicular required.

Fig. 1.—*Plate,* PRACTICAL GEOMETRY.

To let fall a perpendicular.

From D as a centre, and with any radius, describe an arc intersecting the given line. From the points of intersection C, and E, with any radius greater than half, describe two arcs, cutting each other at F. Through D, and F draw a line, and D F will be the perpendicular required. *Fig.* 2.

To draw a line parallel to a given line.

From any point D in the given line with the radius D C, describe the arc C E, and from C with the same radius describe the arc D F. Take E C, and set it off from D to F. Through C, and F draw C F for the parallel required. *Fig.* 3.

To divide an angle into two equal parts.

From B as a centre with any radius describe an arc A C. From A, and C with any radius describe arcs intersecting each other in D. Then draw B D, and it will bisect the angle. *Fig.* 4.

To divide a right angle into three equal parts.

From B as a centre with any radius describe the arc A C. From A with the radius A B cut the arc A C in D, and with the same radius from C cut it in E. Then through the intersections D, and E draw the lines B D, B E, and they will trisect, or divide the angle into three equal parts. *Fig.* 5.

To find the centre of a circle.

Draw any chord A B, and bisect it by the perpendicular C D. Divide C D into two equal parts, and the point of bisection O will be the centre required. *Fig.* 6.

To describe an equilateral triangle.

From the points A, B, as centres, and with A B as radius, describe arcs intersecting each other in C. Draw C A, C B, and the figure A B C will be the triangle required. *Fig.* 7.

To describe a square.

From the point B, draw B C perpendicular, and equal to A B. On A, and C, with the radius A B, describe arcs cutting each other in D. Draw the lines D A, D C, and the figure A B C D will be the square required. *Fig.* 8.

To inscribe a square in a circle.

Draw the diameters A B, C D perpendicular to each other. Then draw the lines A D, A C, B D, B C; and A B C D will be the square required. *Fig.* 9.

To inscribe an octagon in a circle.

Bisect any two arcs A C, B C of the square A B C D in G, and E. Through the points G, and E, and the centre O draw lines, which produce to F, and H. Join A F, F D, D H, &c. and they will form the octagon required. *Fig.* 9.

On a line to describe all the several polygons, from the hexagon to the dodecagon.

Bisect A B by the perpendicular C D. From A as a centre, and with A B as a radius, describe the arc B E, which divide into six equal parts; and from E as a centre describe the arcs 5 F, 4 G, 3 H, &c. Then from the intersection E as a centre, and with E A as a radius, describe the circle A I D B, which will contain A B six times. From F in like manner as a centre, and with F A as radius, describe the circle A K L B, which will contain A B seven times; and so on for the other polygons. *Fig.* 10.

To inscribe in a circle an equilateral triangle.

From any point D in the circumference as a centre, and with the radius D O of the given circle, describe an arc A O B cutting the circumference in A, and B. Through D, and O draw D C. Then, join A B, A C, B C; and the figure A B C will be the triangle required. *Fig.* 11.

PRACTICAL GEOMETRY.

Fig. 10.

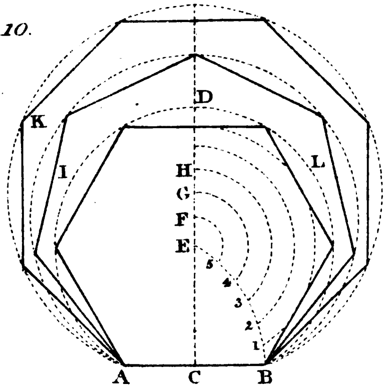
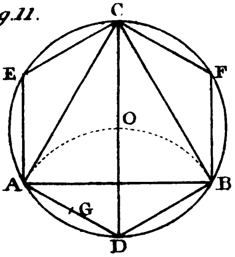


Fig. 11.



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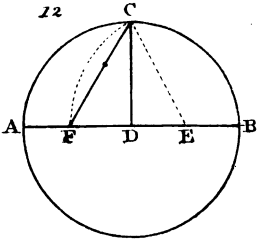

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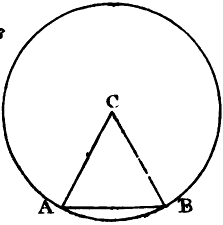

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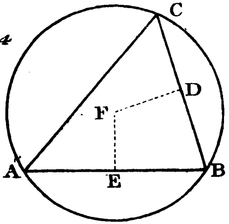

To inscribe a hexagon in a circle.

Bisect the arcs A C, B C in E, and F, and join A D, D B, B F, &c., which will form the hexagon. Or carry the radius six times round the circumference, and the hexagon will be obtained. *Fig.* 11.

To inscribe a dodecagon in a circle.

Bisect the arc A D of the hexagon in G, and A G being carried twelve times round the circumference, will form the dodecagon. *Fig.* 11.

To inscribe a pentagon, hexagon, or decagon, in a circle.

Draw the diameter A B, and make the radius D C perpendicular to A B. Bisect D B in E. From E as a centre, and with E C as radius, describe an arc cutting A D in F. Join C F, which will be the side of the pentagon, C D that of the hexagon, and D F that of the decagon. *Fig.* 12.

To find the angles at the centre, and circumference of a regular polygon.

Divide 360 by the number of the sides of the given polygon, and the quotient will be the angle at the centre; and this angle being subtracted from 180°, the difference will be the angle, at the circumference, required.

Table, showing the angles at the centre, and circumference.

Names.	No. of sides.	Angles at centre.	Angles at circumference.
Trigon	3	120°	60°
Tetragon	4	90°	90°
Pentagon	5	72°	108°
Hexagon	6	60°	120°
Heptagon	7	$51^\circ\ 25\frac{5}{7}'$	$128^\circ\ 34\frac{2}{7}'$
Octagon	8	45°	135°
Nonagon	9	40°	140°
Decagon	10	36°	144°

To inscribe any regular polygon in a circle.

From the centre C draw the radii C A, C B, making an angle equal to that at the centre of the proposed polygon, as contained in the preceding table. Then the distance A B will be one side of the polygon, which, being carried round the circumference the proper number of times, will complete the polygon required. *Fig.* 13.

To circumscribe a circle about a triangle.

Bisect any two of the given sides, A B, B C by the perpendiculars E F, D F. From the intersection F as a centre, and with the distance of any of the angles, as a radius, describe the circle required. *Fig.* 14.

To circumscribe a circle about a square.

Draw the two diagonals A C, B D intersecting each other in O. From O as a centre, and with O A, or O B, as a radius, describe the required circle. *Fig.* 15.

To circumscribe a square about a circle.

Draw the two diameters A B, C D perpendicular to each other, through the points A, C, B, D, draw the tangents E F, E G, G H, F H, and E G H F will be the square required. *Fig.* 16.

To reduce a map, or plan, from one scale to another.

Divide the given figure A C by cross lines, forming as many squares as may be thought necessary. Draw a line E F, on which set off as many parts from the scale M, as A B contains parts of the scale N. Draw E H, and F G perpendicular to E F, and each equal to the proportional parts contained in A D, or B C. Join H G, and divide the figure E G into the same number of squares as the original A C. Describe in every square what is contained in the corresponding square of the given figure; and E F G H will be the reduced plan required. The same operation will serve either to reduce, or enlarge any map, plan, drawing, or painting. *Fig.* 17.

MENSURATION OF PLANES, AND SOLIDS.

Mensuration is of three kinds, viz., lineal, superficial, and solid.

Lineal measure has reference to length only.

Superficial measure (*or the surface*) includes length, and breadth.

Solid measure (*or the content*) comprehends length, breadth, and thickness.

MENSURATION OF PLANES.

The area of any plane figure is the superficial measure contained within its extremes, or bounds. This area is estimated by the number of small squares that may be contained in it, the side of these measuring squares being an inch, a foot, or any other fixed quantity, and hence the area is said to be so many square inches, square feet, &c. *Vide Table, Square measure. Page* 281.

To find the area of a parallelogram, whether a square, rectangle, &c.

Multiply the length by the breadth, or perpendicular height, for the area required.

Example.—Required the area of a rectangle, whose length is 9 feet, and breadth 4 feet.

$9 \times 4 = 36$ feet. The required area, or surface.

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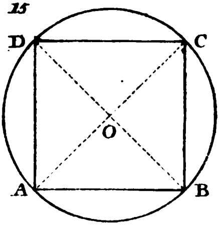

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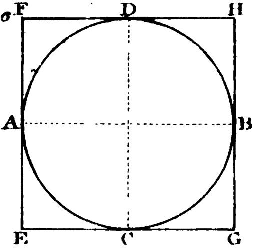

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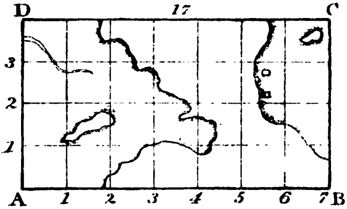

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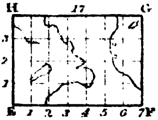

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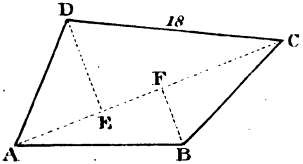

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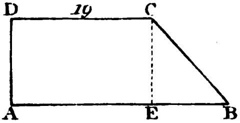

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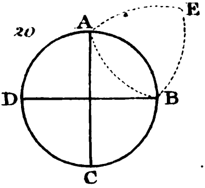

To find the area of a triangle, its base, and perpendicular height being given.

Multiply the base by the perpendicular height, and half the product will be the area.

Example.—Required the number of square yards contained in a triangle, whose base is 20 yards, and perpendicular height 14 yards.

$$\frac{20\times14}{2}=140 \text{ square yards. Area required.}$$

To find the area of a triangle, whose three sides are given.

From half the sum of the three sides, subtract each side severally; multiply the half sum, and the three remainders together, and the square root of the product will be the area required.

Example.—Required the area of a triangle, whose sides are 50, 40, and 30 feet.

$\frac{50+40+30}{2}=60$, half the sum of the three sides.

$60-30=30$ First difference.
$60-40=20$ Second difference.
$60-50=10$ Third difference.
$30\times20\times10\times60=360000$.
Square root of $360000=600$. Area required.

Two sides of a right-angled triangle being given, to find the third side.

1. When the two sides forming the right angle are given, to find the hypothenuse, or side opposite the right angle.

Take the square root of the sum of the two sides squared for the side required.

Example.—Required the length of the interior slope of a rampart, whose perpendicular height is 17 feet, and the base of the slope 20 feet.

$$\begin{array}{r} 17\times17=289 \\ 20\times20=400 \\ \hline \end{array}$$

The square root of $689=26{\cdot}24$. The length required.

2. When the hypothenuse, and one of the perpendicular sides are given.

From the square of the hypothenuse, subtract the square of the given side, and the square root of the remainder will be the side required.

Example.—The hypothenuse being 5 yards, and the base 4 yards, required the other side.

$$\begin{array}{r} 5\times5=25 \\ 4\times4=16 \\ \hline \end{array}$$

The square root of $9=3$ yards. The side required.

To find the area of a trapezium, A B C D.

Draw the diagonal A C, upon which let fall from its opposite angles B, and D, the perpendiculars B F, D E. Find by measurement the diagonal A C, and the perpendiculars B F, D E, then multiply the sum of the perpendiculars by the diagonal, and half the product will be the area of the trapezium.—*Fig.* 18.

Example.—Required the area of the trapezium, whose diagonal A C is 100 feet, and perpendiculars B F 30 feet, and D E 40 feet.

$$\frac{\overline{30+40}\times 100}{2}=3500 \text{ square feet. Area required.}$$

Or, divide the trapezium into two triangles by a diagonal, then find the areas of these triangles, and add them together.

To find the area of a trapezoid, A B C D.

Multiply the sum of the parallel sides A B, D C by the perpendicular distance E C, and half the product will be the area. *Fig.* 19.

Example.—Required the area of the trapezoid A B C D, of which the parallel sides A B, D C are 120 feet, and 90 feet, and the perpendicular distance E C 40 feet.

$$\frac{\overline{120+90}\times 40}{2}=4200 \text{ square feet. Area required.}$$

To find the area of an irregular figure, or polygon.

Draw diagonals dividing the figure into trapeziums, and triangles; then, having found the area of each, add them together, and the sum will be the area required.

To find the area of a figure, having a part bounded by a curve.

Draw a right line joining the extremities of the curve, then find the area of the trapezium. On the right line let fall as many perpendiculars as the several windings of the curve may require. Find their lengths, and divide their sum by the number of perpendiculars, and the quotient will be the mean breadth; which being multiplied by the length of the right line, will give the area of the curved part. This area being added to that of the trapezium will give the area of the required figure.

To measure long irregular figures.

Measure the breadth at both ends, and at several places *at equal distances.* Add together all these intermediate breadths, and half the two extremes, which sum multiply by the length, and divide by the number of parts for the area. If the perpendiculars, or breadths, *be not at equal distances,* compute all the parts separately, as so many trapezoids, and add them all together for the whole area.

Example.—The breadths of an irregular figure at five equidistant places being 8, 2, 7, 9, 4, and the whole length 40, required the area.

$$8+4=12 \qquad 12\div 2=6$$

$$6+2+7+9=24$$

$$\frac{24\times 40}{4}=240.$$ Area required.

*To find the number of square acres in any of the preceding figures.**

Divide the superficial content in feet by 43560 (or in yards by 4840), and the quotient will be the number required.

To bring square chains to acres.

Of square chains strike off two decimal places to the right, and the rest of the figures will be acres.

To bring square links to acres, roods, and perches.

Of square links cut off five of the figures on the right hand, for decimals; and the rest will be acres; then multiply these decimals by 4, for roods, cutting off five figures as before; and the decimals of these again by 40, for perches, when five figures are again to be struck off.

To find the area of a regular polygon.

Multiply the *perimeter* (or sum of the sides) of the polygon by the perpendicular drawn from its centre on one of its sides, and take half the product for the area.

Or, multiply the area of one of the triangles by the number of sides of the polygon, and the product will be the area of it.

Example.—Required, the area of a regular hexagon, whose side is 40 feet, and the perpendicular 34·64 feet.

$$40 \times 6 = 240$$ the perimeter.

$$\frac{240 \times 34{\cdot}64}{2} = 4156{\cdot}8$$ square feet. Area required.

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* *Gunter's chain* is in length 4 poles = 22 yards = 66 feet, and is divided into 100 links. Each link is therefore $\frac{22}{100}$ of a yard, or $\frac{66}{100}$ of a foot, or 7·92 inches. *Land is estimated* in acres, roods, and perches. *An acre* contains 10 square chains, or as much as 10 chains in length and 1 chain in breadth; or in yards it is 220 × 22 = 4840; or in poles it is 40 × 4 = 160 square poles; or in links it is 1000 × 100 = 100,000 square links. An acre is divided into 4 parts called roods, and a rood into 40 parts called perches, which are square poles, or the square of a pole of $5\frac{1}{2}$ yards long, or the square of a quarter of a chain, or of 25 links, which is 625 links. Thus the divisions of land measure are—

625 square links = 1 pole, or perch.
40 perches = 1 rood.
4 roods = 1 acre.

The length of lines, measured with a chain, should be set down in links as integers, instead of in chains, and decimals. Therefore, after the content is found, it will be in square links.

To find the diameter, and circumference of any circle, the one from the other.

Use either of the following proportions:

$$\left.\begin{array}{l}\text{as 7 is to 22}\\ \text{or as 1 is to 3·1416}\end{array}\right\}\ \left\{\begin{array}{l}\text{so is the diameter}\\ \quad\text{to the circumference.}\end{array}\right.$$

$$\left.\begin{array}{l}\text{as 22 is to 7}\\ \text{or as 3·1416 is to 1}\end{array}\right\}\ \left\{\begin{array}{l}\text{so is the circumference}\\ \quad\text{to the diameter.}\end{array}\right.$$

or, instead of dividing the diameter by 3·1416, multiply it by ·3183, for the circumference.

Example 1.—Required, the circumference of a circle, whose diameter is 20 feet.

As 7 : 22 : : 20 : 62·857 feet. Circumference required.

Example 2.—Required, the diameter of a circle, whose circumference is 36 inches.

As 22 : 7 : : 36 : 11·45 inches. Diameter required.

To find the diameter of a circle, the area being given.

Divide the area by ·7854, and the square root of the quotient will be the diameter required.

Example.—Required, the diameter of a circle, whose area is 176·715 square feet.

176·715 ÷ 7854 = 225.

Square root of 225 = 15 feet. Diameter required.

To find the area of a circle.

1. Multiply half the circumference by half the diameter, or multiply the whole circumference by the whole diameter, and take $\frac{1}{4}$ of the product.

2. Or, square the diameter, and multiply that square by ·7854 for the area.

3. Or, square the circumference, and multiply that square by ·7958.

Example 1.—Required the area of a circle, whose circumference is 55·548 inches, and its diameter 18 inches.

$$\frac{55·548}{2} = 27·774 \text{ half circumference.}$$

$$\frac{18}{2} = 9 \text{ half diameter.}$$

27·774 × 9 = 249·966, square inches. Area required.

Example 2.—Required the area of a circle whose diameter is 12 feet.

12 × 12 = 144, square of the diameter.

·7854 × 144 = 113·0976 square feet. Area required.

Example 3.—Required the area of a circle, whose circumference is 22 feet.

22 × 22 = 484.

484 × ·07958 = 38·51672 square feet, Area required.

To find the area of a circular ring,

or space included between the circumferences of two circles, the one within the other.

1. Subtract the square of the less diameter from the square of the greater, and multiply their difference by ·7854.

2. Or, find the area of each circle separately, and subtract one from the other, for the area required.

3. Or, multiply the sum of the diameters by the difference of the same, and that product by ·7854 for the area.

Example.—Required the area of a ring, the diameters of whose bounding circles are 10, and 20.

By Rule 3,

20 + 10 = 30, sum of diameters.

20 − 10 = 10, difference of diameters.

30 × 10 × ·7854 = 235·62. The area.

To find the length of any arc of a circle.

1. As 360° is to the number of degrees in the arc, so is the circumference to the length of the arc.

2. Or, multiply the degrees in the given arc by the radius of the circle, and the product by ·01745 for the length of the arc.

Example.—*Rule* 2.—Required the length of an arc of 30°, the radius being 9 feet.

30 × 9 × ·01745 = 4·7115. Length of arc.

To find the area of the sector of a circle.

Multiply the radius by the arc, and half the product will be the area.

Example.—Required the area of the sector, whose radius is 30 inches, and the length of the arc 36·6 inches.

$$\frac{36{\cdot}6 \times 30}{2} = 549 \text{ square inches. Area required.}$$

To find the area of the segment of a circle.

Find the area of the sector, by the preceding rule. Then find the area of the triangle formed by the chord of the segment, and the radii of the sector. Then, if the segment be less than a semicircle, subtract the area of the triangle from it; or, if the segment be greater than a semicircle, add the area of the triangle to it; for the area of the segment.

Example.—Required the area of a segment less than a semicircle, the radius being 20 inches, the chord 22·42 inches, the length of the arc 24·43 inches, and the perpendicular 16·56 inches.

$$\frac{24{\cdot}43 \times 20}{2} = 244{\cdot}3 \text{ square inches. Area of the sector.}$$

$$\frac{22{\cdot}42 \times 16{\cdot}56}{2} = 185{\cdot}6376 \left\{\begin{array}{l}\text{square inches.}\\ \text{Area of the triangle.}\end{array}\right.$$

$$244{\cdot}3 - 185{\cdot}6376 = 58{\cdot}6624 \left\{\begin{array}{l}\text{square inches.}\\ \text{Area required.}\end{array}\right.$$

To find the area of a semicircle.

1. Multiply ½ of the circumference by the radius, and the product will be the area.
2. Or, multiply the square of the diameter by ·7854, and half the product will be the area.

Example.—*Rule* 2.—Required the area of a semicircle, the diameter being 50 inches.

$$\frac{50 \times 50 \times {\cdot}7854}{2} = 981{\cdot}75 \left\{\begin{array}{l}\text{square inches.}\\ \text{Area required.}\end{array}\right.$$

To find the area of an ellipsis, or oval.

Multiply the longest diameter, or axis, by the shortest, then multiply the product by ·7854 for the area.

Example.—Required the area of the ellipse, whose diameters are 25 inches, and 18 inches.

$$25 \times 18 \times {\cdot}7854 = 353{\cdot}43 \text{ square inches. Area required.}$$

To find the area of a parabola, or its segment.

Multiply the base by the perpendicular height, and take two-thirds of the product for the area.

Example.—Required the area of a parabola, whose base is 20 feet, and height 12 feet.

$20 \times 12 = 240$
⅔ of 240 = 160 square feet. Area required.

MENSURATION OF SOLIDS.

A solid is a body containing length, breadth, and thickness.

Solids are measured by cubes, whose sides are each an inch, a foot, a yard, &c., and the solidity, capacity, or content of any figure is computed by the number of such cubes as are contained in it.—*Vide* CUBIC MEASURE, *page* 282.

A cube is a solid contained by six equal square sides.

A pyramid is a solid whose sides are all triangles meeting together in a point, the base being any plane figure whatever. It is called a triangular pyramid when its base is a triangle; a square pyramid when its base is a square, &c.

The segment of a pyramid, cone, or any other solid is a part of D E F G cut off from the top by a plane D E F, parallel to the base A B C.— *Vide Fig.* 21, *Plate* 2, HEIGHTS, DISTANCES, and PRACTICAL GEOMETRY.

A frustrum, or trunk, is a part, A B C D E F, that remains at the bottom after the segment is cut off.

A cone is a round pyramid, of which the base is a circle.

The axis of a solid is a line from the vertex (or point) to the centre of the base, or through the centres of the two ends. When the axis is perpendicular to the base, it is a right prism, pyramid, or cone ; otherwise it is oblique.

A sphere is a solid contained under one convex surface, and is described by the revolution of a semicircle about its diameter, which remains fixed.

The centre of the sphere is such a point within the solid as is everywhere equally distant from the convex surface, or circumference of it.

The diameter (or axis) of a sphere is a straight line, which passes through the centre, and is terminated by the convex surface.

A segment of a sphere is a part cut off by a plane, the section of which is always a circle, called the *base of the segment.*

A sector of a sphere is that which is composed of a segment (less than a hemisphere) and of a cone.

A prism is a solid, the sides of which are parallelograms, having its ends equal, and similar plane figures.

Prisms are named according to the number of angles in the base.

A cylinder is a solid, the two ends of which are circular; and it is described, or formed, by the revolution of a right-angled parallelogram about one of its sides, which remains fixed.

To find the superficies of a prism, or cylinder.

Multiply the perimeter of one end of the prism by the length, or height of the solid, and the product will be the surface of all its sides. To which add also the area of the two ends of the prism, when required.

Or, compute the areas of all the sides, and ends separately, and add them all together.

Example.—Required the surface of a cube, whose sides are each 5 inches.

$5 + 5 + 5 + 5 = 20$, perimeter of one end.
$20 \times 5 = 100$, surface of sides.
$5 \times 5 = 25$, area of one end.
$100 + 25 + 25 = 150$ square inches. Surface of cube.

To find the surface of a pyramid, or cone.

Multiply the perimeter of the base by the slant height, or length of the side, and half the product will be the surface of the sides; to which add the area of the base when required.

Example.—Required the upright surface of a triangular pyramid, the slant height being 20 feet, and each side of the base 3 feet.

$3 + 3 + 3 = 9$, perimeter of base.

$\frac{9 \times 20}{2} = 90$ feet. Surface required.

To find the surface of the frustrum of a pyramid, or cone.

Add together the perimeters of the two ends, multiply their sum by the slant height, and take half the product.

Example.—How many square feet are in the surface of the frustrum of a square pyramid, whose slant height is 10 feet, each side of the base 3 feet, and each side of the less end 2 feet.

$3 + 3 + 3 + 3 = 12$, perimeter of base.
$2 + 2 + 2 + 2 = 8$, perimeter of less end.

$\frac{\overline{12 + 8} \times 10}{2} = 100$ feet. Surface required.

To find the solid content of a prism, or cylinder.

Find the area of the base, or end, and multiply it by the length of the prism, or cylinder. For a cube, multiply its side twice by itself; and for a parallelopipedon, multiply the length, breadth, and depth together for the content.

Example.—Required the solid content of a cube, whose side is 24 inches.

$24 \times 24 \times 24 = 13824$ square inches. Content required.

To find the content of the solid part of a hollow cylinder.

From the content of the whole cylinder considered as a solid, subtract the content of the hollow part, also considered as a solid, and the difference will be the solidity required.

Example.—Required the content of the solid part of the hollow cylinder whose exterior diameter is 12 inches, the interior diameter 8 inches, and height 20 inches.

$12 \times 12 \times \cdot7854 = 113\cdot0976$, area of base of cylinder.
$113\cdot0976 \times 20 = 2261\cdot952$, solidity of whole cylinder.
$8 \times 8 \times \cdot7854 = 50\cdot2656$, area of base of hollow cylinder.
$50\cdot2656 \times 20 = 1005\cdot312$, content of hollow part.
$2261\cdot952 - 1005\cdot312 = 1256\cdot64$ cubic inches. Solidity required.

To find the solidity of the frustrum of a cylinder.

Multiply the area of the base by half the greatest, and the least lengths, and the product will be the solidity.

Example.—Required the solidity of a frustrum, whose diameter is 24 inches, the greatest length 36 inches, and the least length 20 inches.

$24 \times 24 = 576$. Square of the diameter.
$576 \times \cdot 7854 = 452 \cdot 3904$. Area of the base.

$$452 \cdot 3904 \times \frac{36 + 20}{2} = 12666 \cdot 9312 \left\{ \begin{array}{l} \text{Cubic inches.} \\ \text{Solidity required.} \end{array} \right.$$

To find the content of a pyramid, or cone.

Find the area of the base, and multiply that area by the perpendicular height, and take $\frac{1}{3}$ of the product.

Example.—Required the solidity of a square pyramid, each side of its base being 30, and its perpendicular height 25.

$30 \times 30 = 900$, area of base.

$$\frac{900 \times 25}{3} = 7500, \text{ Solidity required.}$$

To find the solidity of the frustrum of a cone, or pyramid.

Add into one sum the areas of the two ends, and the mean proportional between them: take $\frac{1}{3}$ of that sum for the mean area, which multiply by the perpendicular height, or length of the frustrum.

Note.—To find a mean proportional.
As one of the sides of the base is to the homologous, or corresponding side of the other end, so is the area of the base to the mean proportional required.

Example.—Required the number of solid feet in a piece of timber, whose bases are squares, each side of the greater end being 15 inches, and each side of the less end 6 inches; also the length of the perpendicular altitude 24 feet.

$15 \times 15 = 225$, area of the base.
$6 \times 6 = 36$, area of the top.
As $15 : 6 :: 225 : 90$, mean proportional.
24 feet = 288 inches.

$$\frac{\overline{225 + 36 + 90} \times 288}{3} = 33696 \text{ cubic inches} = 19\tfrac{1}{2} \text{ cubic feet.}$$

To find the surface of a sphere, or any segment.

Multiply the circumference of the sphere by its diameter, which will give the whole surface.
Or, square the diameter, and multiply by $3 \cdot 1416$.
Or, square the circumference, and multiply by $\cdot 3183$;
or divide by $3 \cdot 1416$.

Note.—For the surface of the segment, or frustrum, multiply the whole circumference of the sphere by the height of the part required.

Example.—Required the superficies of a globe whose diameter is 24 inches.

$24 \times 24 \times 3\cdot1416 = 1809\cdot5616$ square inches.

To find the solidity of a sphere, or globe.

1. Multiply the surface by the diameter, and take $\frac{1}{6}$ of the product. Or, multiply the square of the diameter by the circumference, and take $\frac{1}{6}$ of the product.
2. Cube the diameter, and multiply by ·5236.
3. Cube the circumference, and multiply by ·01688.

Example.—Required the content of a sphere, whose axis is 12.
$12 \times 12 \times 12 \times \cdot5236 = 904\cdot7808$. Content required.

To find the solidity of a hemisphere.

Find the solidity of the sphere, and half the content will be that of the hemisphere.

Note 1.—Any sphere, or globe *twice* the diameter of another contains *four times* the superficies, or area of the other, and *eight times* the solid content. Hence the superficies of spheres are as the squares, and the solidity as the cubes of their diameters.

Note 2.—The cube of the diameter of a sphere in inches, multiplied by ·00188, will give the number of *imperial gallons it will contain.*

To find the solid content of a spherical segment.

1. From three times the diameter of the sphere, take double the height of the segment; then multiply the remainder by the square of the height, and this product by ·5236.
2. Or, to three times the square of the radius of the segment's base add the square of its height; then multiply the sum by the height, and the product by ·5236.

Example.—Required the content of a spherical segment 2 feet in height, cut from a sphere of 8 feet diameter.

$(3 \times 8) - (2 \times 2) = 20$
$20 \times 2^2 \times \cdot5236 = 41\cdot888$ cubic feet. Content required.

To find the diameter of a sphere, its solidity being given.

Divide the solidity by ·5236, and take the cube root of the quotient.

Example.—The solidity of a sphere being 113·0976 solid inches, what will be its diameter?

$\frac{113\cdot0976}{\cdot5236} = 216$, the cube root of which is 6 inches, the diameter required.

To find the weight of an iron shot, its diameter being given.

Take $\frac{1}{8}$ of the cube of the diameter, and $\frac{1}{8}$ of that eighth, and the sum of these two quotients will be the weight in pounds.

Or, as 64 is to 9 lb., so is the diameter cubed to its weight.

Example.—Required the weight of an iron shot whose diameter is 3·5 inches?

3·5 cubed = 42·875, cube of diameter.

$\frac{42 \cdot 875}{8} = 5 \cdot 359$ $\qquad$ $\frac{5 \cdot 359}{8} = \cdot 669$

$5 \cdot 359 + \cdot 669 = 6 \cdot 028$ pounds. Weight required.

To find the weight of a leaden ball, its diameter being given.

Take $\frac{1}{3}$ of the cube of the diameter, and from it subtract $\frac{1}{3}$ of this third, and the remainder will be the weight, nearly.

Or, take $\frac{3}{14}$ of the cube of the diameter.

Example.—What is the weight of a leaden ball whose diameter is 3·3 inches?

3·3 cubed = 35·937, cube of diameter.

$\frac{35 \cdot 937}{3} = 11 \cdot 979$ $\qquad$ $\frac{11 \cdot 979}{3} = 3 \cdot 993$

$11 \cdot 979 - 3 \cdot 993 = 7 \cdot 986$ pounds. Weight required.

To find the diameter of an iron shot, its weight being given.

Multiply the cube root of the shot's weight by 1·923 for the diameter.

Pr.	Cube root.		Diameter.
42	3·4760, &c.	Multiplied by 1·923, diameter of a 1 lb. shot.	6·684, &c.
32	3·1748		6·103 „
24	2·8844		5·545 „
18	2·6207		5·038 „
12	2·2894		4·401 „
9	2·0800		3·999 „
6	1·8171		3·494 „
3	1·4422		2·772 „

To find the diameter of a leaden ball, its weight being given.

To 4 times the weight add half the weight, and $\frac{3}{100}$ of half the weight; and the cube root of this sum will be the diameter in inches, nearly.

Example.—What is the diameter of a leaden ball, whose weight is 8 pounds?

$8 \times 4 = 32$ $\qquad$ $\frac{8}{2} = 4$ $\qquad$ $\frac{3}{100}$ of $4 = \cdot 12$.

$32 + 4 + \cdot 12 = 36 \cdot 12$, of which the cube root is 3·3 inches, nearly. Diameter required.

To find the weight of an iron shell, its interior, and exterior diameter being given.

Take $\frac{9}{64}$ of the difference of the cubes of the external, and internal diameters, for the weight of the shell in pounds.

Example.—What is the weight of a shell whose exterior diameter is 12·85 inches, and interior diameter 8·75 inches?

12·85 cubed = 2121·8241, 8·75 cubed = 669·9218.
2121·8241 − 669·9218 = 1451·9022.
$\frac{9}{64}$ of 1451·9022 = 204·1737 pounds. Weight required.

To find the quantity of powder a shell will contain.

Divide the cube of the interior diameter in inches by 57·3, and the quotient will be the weight in pounds.

Or, multiply the cube of the diameter by 11, and divide by 21 for the quantity in half ounces.

Example.—How much powder will fill a shell, whose internal diameter is 7 inches?

7 cubed = 343.

$\frac{343}{57\cdot3}$ = 6 pounds nearly. Powder required.

To find the side of a cubical box to contain a given quantity of powder.[*]

Multiply the weight in pounds by 30, and the cube root of the product will be the side of the box in inches.

Example.—Required the side of a cubical box to hold 50 pounds of powder?

50 × 30 = 1500, the cube root of which is 11·44, which will be the side of the box in inches.

To find the quantity of powder to fill the chamber of a mortar, or howitzer.

Multiply the content of the chamber in inches by 55, and divide the product by 1728, and the quotient will be the quantity of powder in pounds.

Note.—The chamber of a mortar, or howitzer, is formed of a hollow frustrum of a right cone, and of a hollow hemisphere.

Example.—Required the quantity of powder to fill the chamber of a 13-inch mortar in which the diameter A B is 9·5 inches, the diameter

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[*] 57·3 is the number of pounds of powder contained in a cubic foot, when shaken; and 55 pounds when not shaken. According to the first case, one pound of powder will occupy 30 cubic inches; and according to the second case, one pound will occupy 31·4182 cubic inches.

C E 6·5 inches, and the length D G 21·5 inches. *Vide Fig.* 22. *Plate* 2. HEIGHTS AND DISTANCES, and PRACTICAL GEOMETRY.

The content of the chamber must be found by finding the content of the hollow frustrum of the cone, and that of the hemisphere (*vide preceding rules*): which in this example will be 999·9741875.

$$\text{Then } \frac{999{\cdot}9741875 \times 55}{1728} = 31 \text{ pounds, nearly.}$$

To find the quantity of powder to fill a rectangular box.

Divide the content (viz., length × breadth × depth) of the box in inches by 30 for the pounds of powder.

Example.—How much powder will fill a box, the length being 15 inches, the breadth 12, and the depth 10 inches?

$$\frac{15 \times 12 \times 10}{30} = \frac{1800}{30} = 60 \text{ pounds.} \quad \text{Number required.}$$

To find the quantity of powder to fill a cylinder.

Multiply the square of the diameter by the length, then divide by 38·2 for the pounds of powder.

Example.—How much powder will the cylinder contain, whose diameter is 10 inches, and length 20 inches?

$$\frac{10 \times 10 \times 20}{38{\cdot}2} = 52\tfrac{1}{3} \text{ pounds, nearly.}$$

To find the size of a shell, to contain a given weight of powder.

Multiply the pounds of powder by 57·3, and the cube root of the product will be the diameter in inches.

Example.—Required the diameter of a shell to contain 6 lb. of powder?

$6 \times 57{\cdot}3 = 343{\cdot}8$, the cube root of which is 7, the diameter required, in inches.

To find what length of a cylinder (or bore of a gun) will be filled by a given weight of powder.

Multiply the weight in pounds by 38·2, and divide the product by the square of the diameter in inches, for the length.

Example.—What length of a cylinder 8 inches in diameter will be filled with 20 lb. of powder?

$$\frac{20 \times 38{\cdot}2}{8 \times 8} = 11\tfrac{15}{16} \text{ inches.}$$

To find the content, and weight of a piece of ordnance.

Divide the length of the gun into as many sections as may be found necessary. Find the content of each (*by preceding rules*) and from their sum subtract the content of a cylinder, whose length is equal to that of the bore, and its diameter equal to that of the calibre of the piece; multiply the difference (if it be a brass gun) by 5·0833, (if an iron gun) by 4·2968, and the product will be the weight in ounces.

Note.—A cubic inch of gun metal weighs 5·0833 ounces.
Ditto of *cast* iron 4·2968 ounces.

To find the content of a cask.

Multiply half the sum of the areas of the two interior circles, viz. at the head, and bung, by the interior length, for the content.

Or, to the area of the head add twice the area at the bung, multiply that sum by the length, and take one-third of the product.

Example.—Required the content of a cask, its greatest interior diameter being 24 inches, its least interior diameter 20 inches, and the interior length 30 inches.

$24 \times 24 \times {\cdot}7854 = 452{\cdot}3904$, area of large circle.
$20 \times 20 \times {\cdot}7854 = 314{\cdot}1600$, area of small circle.

$$\frac{452{\cdot}3904 + 314{\cdot}1600}{2} = 383{\cdot}2752, \text{ half sum.}$$

Then $383{\cdot}2752 \times 30 = 11498{\cdot}256$, the content; which being divided by $277\frac{1}{4}$ (the number of cubic inches in a gallon) will give the number of gallons contained in the cask.

Thus $\frac{11498{\cdot}256}{277{\cdot}25} = 41{\cdot}4725$, &c. Number of gallons required.

Note.—The content of any vessel in cubic feet, multiplied by 6·232 (or if in inches by ·003607) will give the number of *imperial gallons it will contain.*

EPITOME OF MENSURATION.

OF THE CIRCLE, CYLINDER, SPHERE, ETC.

1. The circle contains a greater area than any other plane figure, bounded by an equal perimeter, or outline.

2. The areas of circles are to each other as the squares of their diameters; any circle twice the diameter of another contains four times the area of the other.

3. The diameter of a circle being 1, its circumference equals 3·1416.

4. The diameter of a circle is equal to ·31831 of its circumference.

5. The square of the diameter of a circle being 1, its area equals ·7854.

6. The square root of the area of a circle, multiplied by 1·12837, equals its diameter.

7. The diameter of a circle, multiplied by ·8862, or the circumference multiplied by ·2821, equals the side of a square of equal area.

8. The sum of the squares of half the chord, and versed sine, divided by the versed sine, the quotient equals the diameter of the corresponding circle.

9. The chord of the whole arc of a circle taken from eight times the chord of half the arc, one-third of the remainder equals the length of the arc.

10. Or, the number of degrees contained in the arc of a circle, multiplied by the diameter of the circle, and by ·008727, the product equals the length of the arc in equal terms of unity.

11. The length of the arc of the sector of a circle multiplied by its radius, half the product is the area.

12. The area of the segment of a circle equals the area of the sector, minus the area of a triangle whose vertex is the centre, and base equals the chord of the segment.

13. The sum of the diameters of two concentric circles multiplied by their difference, and by ·7854, equals the area of the ring, or space contained between them.

14. The sum of the thickness, and internal diameter of a cylindric ring multiplied by the square of its thickness, and by 2·4674, equals its solidity.

15. The circumference of a cylinder multiplied by its length, or height, equals its convex surface.

16. The area of the end of a cylinder multiplied by its length, equals its solid content.

17. The area of the internal diameter of a cylinder multiplied by its depth, equals its cubical capacity.

18. The square of the diameter of a cylinder multiplied by its length, and divided by any other required length, the square root of the quotient equals the diameter of the other cylinder of equal solidity, or capacity.

19. The square of the diameter of a sphere multiplied by 3·1416 equals its convex surface.

20. The cube of the diameter of a sphere multiplied by ·5236, equals its solid content.

21. The height of any spherical segment, or zone, multiplied by the diameter of the sphere, of which it is a part, and by 3·1416, equals the area, or convex surface of the segment;

22. Or, the height of the segment multiplied by the circumference of the sphere of which it is a part, equals the area.

23. The solidity of any spherical segment is equal to three times the square of the radius of its base, plus the square of its height, and multiplied by its height, and by ·5236.

24. The solidity of a spherical zone equals the sum of the squares of the radii of its two ends, and one-third the square of its height, multiplied by the height, and by 1·5708.

25. The solidity of the middle zone of a sphere equals the sum of the square of either end, and two-thirds the square of the height, multiplied by the height, and by ·7854.

26. The capacity of a cylinder 1 foot in diameter, and 1 foot in length, equals 4·895 imperial gallons.

27. The capacity of a cylinder 1 inch in diameter, and 1 foot in length, equals ·034 of an imperial gallon.

28. The capacity of a cylinder 1 inch in diameter, and 1 inch in length, equals ·002832 of an imperial gallon.

29. The capacity of a sphere 1 foot in diameter, equals 3·263 imperial gallons.

30. The capacity of a sphere 1 inch in diameter, equals ·001888 of an imperial gallon.

31. Hence the capacity of any other cylinder in imperial gallons is obtained by multiplying the square of its diameter by its length; or the capacity of any other sphere by the cube of its diameter, and by the number of imperial gallons contained as above in the unity of its measurement.

OF THE SQUARE, RECTANGLE, CUBE, ETC.

1. The side of a square equals the square root of its area.

2. The area of a square equals the square of one of its sides.

3. The diagonal of a square equals the square root of twice the square of its side.

4. The side of a square is equal to the square root of half the square of its diagonal.

5. The side of a square, equal to the diagonal of a given square, contains double the area of the given square.

6. The area of a rectangle equals its length multiplied by its breadth.

7. The length of a rectangle equals the area divided by the breadth; or the breadth equals the area divided by the length.

8. The side, or end of a rectangle, equals the square root of the sum of the diagonal, and opposite side to that required, multiplied by their difference.

9. The diagonal in a rectangle equals the square root of the sum of the squares of the base, and perpendicular.

10. The solidity of a cube equals the area of one of its sides multiplied by the length of one of its edges.

11. The edge of a cube equals the cube root of its solidity.

12. The capacity of a 12-inch cube equals 6·232 gallons.

Surfaces, and Solidities of the regular bodies, when the linear edge is 1.

No. of Sides.	Names.	Surfaces.	Solids.
4	Tetrahedron .	1·7320508	0·1178513
6	Hexahedron .	6·	1·
8	Octahedron . .	3·4641016	0·4714045
12	Dodecahedron .	20·6457788	7·6631189
20	Icosahedron. .	8·6602540	2·1816950

The tabular surface multiplied by the square of the linear edge, the product equals the surface required:

Or, the tabular solidity, multiplied by the cube of the linear edge, the product is the solidity required.

OF TRIANGLES, POLYGONS, ETC.

1. The complement of an angle is its defect from a right angle.

2. The supplement of an angle is its defect from two right angles.

3. The sine, tangent, and secant of an angle, are the cosine, cotangent and cosecant of the complement of that angle.

4. The hypothenuse of a right-angled triangle being made radii, its sides become the sines of the opposite angles, or the cosines of the adjacent angles.

5. The three angles of every triangle are equal to two right angles; hence the obilque angles of a right-angled triangle are each other's complements.

6. The sum of the squares of the two given sides of a right-angled triangle is equal to the square of the hypothenuse.

7. The difference betweeen the square of the hypothenuse, and given side of a right-angled triangle is equal to the square of the required side.

8. The area of a triangle equals half the product of the base multiplied by the perpendicular height;

9. Or, the area of a triangle equals half the product of the two sides, and the natural sine of the contained angle.

10. The side of any regular polygon multiplied by its apothem, or perpendicular, and by the number of its sides, half the product is the area.

Table of the Areas of regular polygons whose sides are unity.

Name of polygon.	No. of sides.	Apothem, or perpendicular.	Area, when side is one or unity.	Interior angle.		Central angle.	
				°	′	°	′
Triangle .	3	0·2886751	0·4330127	60	0	120	0
Square .	4	0·5	1·	90	0	90	0
Pentagon.	5	0·6881910	1·7204774	108	0	72	0
Hexagon .	6	0·8660254	2·5980762	120	0	60	0
Heptagon.	7	1·0382607	3·6339124	128	$34\frac{2}{7}$	51	$25\frac{3}{7}$
Octagon .	8	1·2071068	4·8284271	135	0	45	0
Nonagon .	9	1·3737387	6·1818242	140	0	40	0
Decagon .	10	1·5338418	7·6942088	144	0	36	0
Undecagon	11	1·7028436	9·3656399	147	$16\frac{4}{11}$	32	$43\frac{7}{11}$
Dodecagon	12	1·8660254	11·1961524	150	0	30	0

The tabular area of the corresponding polygon multiplied by the square of the side of the given polygon, equals the area of the given polygon.

OF ELLIPSES, CONES, FRUSTRUMS, ETC.

1. The square root of half the sum of the squares of the two diameters of an ellipse multiplied by 3·1416 equals its circumference.

2. The product of the two axes of an ellipse multiplied by ·7854 equals its area.

3. The curve surface of a cone is equal to half the product of the circumference of its base multiplied by its slant side, to which, if the area of the base be added, the sum is the whole surface.

4. The solidity of a cone equals one-third of the product of its base multiplied by its altitude, or height.

5. The squares of the diameters of the two ends of the frustrum of a cone added to the product of the two diameters, and that sum multiplied by its height, and by ·2618, equals its solidity.

PART XVI.

TRIGONOMETRY.

Plane trigonometry treats of the relations, and calculations of the sides, and angles of plane triangles.

The measure of an angle is an arc of any circle contained between the two lines which form that angle, the angular point being the centre; and it is estimated by the number of degrees contained in that arc. Hence a right angle being measured by a quadrant, or quarter of a circle, is an angle of 90 degrees. The sum of the three angles of every triangle is equal to 180 degrees, or two right angles; therefore, in a right-angled triangle, taking one of the acute angles from 90 degrees, leaves the other acute angle; and the sum of the two angles in any triangle, taken from 180 degrees, leaves the third angle; or one angle being taken from 180 degrees leaves the sum of the other two angles.

Definitions.

The Sine of an arc is the line drawn from one extremity of the arc perpendicular to the diameter of the circle which passes through the other extremity.

The Versed sine of an arc is the part of the diameter intercepted between the arc, and its sine.

The Supplement of an arc is the difference, in degrees, between the arc, and a semicircle, or 180 degrees.

The Complement of an arc is the difference, in degrees, between the arc, and a quadrant, or 90 degrees.

The Tangent of an arc is a line touching the circle in one extremity of that arc, continued from thence to meet a line drawn from the centre through the other extremity; which last line is called *the Secant* of the same arc.

The Cosine, Cotangent, and Cosecant of an arc are the sine, tangent, and secant of the complement of that arc, *the Co* being only a contraction of the word complement.

The sine, tangent, or secant of an angle is the sine, tangent, or secant of the arc by which the angle is measured, or of the degrees, &c., in the same arc, or angle. *Vide also Definitions,* PRACTICAL GEOMETRY, *page* 311.

There are two Methods of resolving triangles, or the cases of trigonometry—viz., *Construction*, and *Computation*.

1*st method.*—The triangle is constructed by making the sides from a scale of equal parts, and laying down the angles from the protractor. Then, by measuring the unknown parts by the same scale, the solution will be obtained.

2*nd method.*—Having stated the terms of the proposition, resolve it like any other proportion, in which a fourth term is to be found from three given terms, by multiplying the second and third terms together, and dividing the product by the first.

Note.—Every triangle has six parts—viz., three sides, and three angles; and, in every case in trigonometry, there must be given three of these parts to find the other three. Also of the three parts that are given, one of them at least must be a side; because, with the same angles, the sides may be greater, or less, in any proportion.

Computation.

Case 1.—*When a side and its opposite angle are two of the given parts.*

The sides of any triangle having the same proportion to each other, as the sines of their opposite angles; then—

As any one side, is to the sine of its opposite angle; so is any other side, to the sine of its opposite angle.

To find an angle, begin the proportion with a side, opposite to a given angle; and, *to find a side,* begin with an angle opposite to a given side.

Case 2.—*When two sides, and their contained angle, are given.*

As the sum of the two sides, is to the difference of the sides; so is the tangent of half the sum of their opposite angles, to the tangent of half the difference of the same angles. Then by adding half the sum to half the difference the greater angle will be ascertained; and by subtracting half the difference from the half sum the lesser angle will be determined. All the angles being consequently known, the side required will be found, as in *Case* 1.

Case 3.—*When the three sides of a triangle are given, to find the angles.*

Let fall a perpendicular from the greatest angle, on the opposite side, or base, dividing it into two segments; and the whole triangle into two right-angled triangles: then the proportion will be—

As the base, or sum of the segments, is to the sum of the other two sides; so is the difference of those sides, to the difference of the segments of the bases: then add half the difference of the segments to the half sum, or the half base, for the greater segment; and subtract the same for the less segment. Hence, in each of the two right-angled triangles, there will be known two sides, and the right angle opposite to one of them, consequently the other angle will be found by the method in *Case* 1.

Case 4.—*When in a right-angled triangle, one side and the angles are given, to find the other side, or the hypothenuse.*

As radius (*i.e.*, sine of 90°, or tangent of 45°), is to the given side; so is the tangent of its adjacent angle to the other side: and so is the secant of the same angle to the hypothenuse.

USEFUL THEOREMS, AND COROLLARIES.

1. When one line meets another, the angles, which it makes on the same side of the other, are together equal to two right angles.

2. All the angles, which can be made at any point (by any number of lines), on the same side of a right line, are, when taken all together, equal to two right angles: and, as all the angles that can be made, on the other side of the line, are also equal to two right angles; therefore all the angles that can be made quite round a point, by any number of lines, are equal to four right angles. Hence also the whole circumference of a circle, being the sum of all the angles that can be made, about the centre, is the measure of four right angles.

3. When two lines intersect each other, the opposite angles are equal.

4. When one side of a triangle is produced, or extended, the outward angle is equal to the sum of the two inward opposite angles.

5. In any triangle, the sum of all the three angles is equal to two right angles (180°). Hence, if one angle of a triangle be a right angle, the sum of the other two angles will be equal to a right angle, (90°).

6. In any quadrilateral, the sum of all the four inward angles is equal to four right angles.

7. In any right-angled triangle, the square of the hypothenuse (or side opposite to the right angle) is equal to the sum of the squares of the other two sides. Therefore, *to find the hypothenuse,* add together the squares of the other two sides, and extract the square root of that sum: and *to find one of the other sides,* subtract from the square of the hypothenuse the square of the other given side, and extract the square root of the remainder for the side required.

8. $\text{cosine} = \sqrt{(1 - \text{sin.}^2)}$
9. $\text{sine} \div \text{cosine} = \text{tangent.}$
10. $\text{cosine} \div \text{sine} = \text{cotangent.}$
11. $\text{sin.}^2 + \text{cos.}^2 = \text{rad.}^2$
12. $\text{rad.}^2 + \text{tan.}^2 = \text{secant.}^2$
13. $1 \div \text{tan.} = \text{cotangent.}$
14. $1 \div \text{cotan.} = \text{tangent.}$
15. $1 \div \text{sine} = \text{cosecant.}$
16. $1 \div \text{cosine} = \text{secant.}$
17. $1 \div \text{cosecant} = \text{sine.}$
18. $1 \div \text{secant} = \text{cosine.}$
19. $\text{rad.} - \text{cosine} = \text{versed sine.}$

Thus, we may, instead of dividing by a sine, multiply by the cosecant; instead of dividing by a tangent, multiply by the cotangent of the same arc; and so of others.

RIGHT-ANGLED TRIANGLES.

1. $(\text{hypoth.})^2 = \text{base}^2 + \text{perp.}^2$
2. $\text{base}^2 = (\text{hypoth.} + \text{perp.}) \times (\text{hypoth.} - \text{perp.})$
3. $\text{perp.}^2 = (\text{hypoth.} + \text{base}) \times (\text{hypoth.} - \text{base.})$
4. $\text{perp.} = \text{base} \times \text{tan. angle at base.}$
5. $\text{hyp.} = \text{base} \times \text{sec. angle at base.}$

6. perp. ÷ base = tan. angle at base.
7. base ÷ perp. = tan. angle at vertex.
8. hypoth. ÷ base = sec. angle at base.
9. hypoth. ÷ perp. = sec. angle at vertex.
10. base ÷ hypoth. = cosine angle at base.
11. perp. ÷ hypoth. = sine angle at base.

TRIGONOMETRY, WITHOUT LOGARITHMS.*

"In all the more elaborate, and refined operations of trigonometry, it is not only desirable, but necessary to employ some of the larger logarithmic tables, both to save time, and to ensure the requisite accuracy in the results. But in the more ordinary operations, as in those of common surveying, ascertaining inaccessible heights, and distances, reconnoitring, &c., where it is not very usual to measure a distance nearer than within about its thousandth part, or to ascertain an angle nearer than within two or three minutes, it is quite a useless labour to aim at greater accuracy in a numerical result. Why compute the length of a line to the fourth, or fifth place of decimals, when it must depend upon another line, whose accuracy cannot be ensured beyond the unit's place? Or, why compute an angle to seconds, when the instrument employed does not ensure the angles in the data beyond the nearest minute? In the following Table are brought together the *natural sines, and cosines*, &c., to every degree in the quadrant, and this table will be found sufficiently extensive, and correct for the various practical purposes above alluded to. The requisite proportions must, it is true, be worked by multiplication, and division, instead of by logarithms. Yet this by no means involves such a disadvantage as might seem, at first sight. For when the measured lines are expressed by three, or at most, four figures, the multiplications, and divisions are performed nearly as quick, and in some cases quicker, than by logarithms. Then as to accuracy, even in cases where the computer will have to take proportional parts for the minutes of a degree, the result may usually, if not always, be relied upon to within about a minute."

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* In Lieut.-Colonel B. Jackson's scientific "Treatise on Military Surveying &c., &c., &c.," *Portable trigonometry without logarithms*, is thus introduced—

"The following useful application of Trigonometry, by means of the natural sines, tangents, &c., is taken from an early number of that valuable periodical, 'The Mechanics' Magazine,' and will be found particularly suited to the purposes of the military surveyor."

A TABLE OF NATURAL SINES, COSINES, TANGENTS, COTANGENTS, SECANTS, AND COSECANTS,

to every Degree of the Quadrant.

Deg.	Sines.	Cosines.	Tangents.	Cotangents.	Secants.	Cosecants.	
0	·00000	1·00000	·00000	Infinite.	1·00000	Infinite.	90
1	·01745	·99985	·01745	57·2900	1·00015	57·2987	89
2	·03490	·99939	·03492	28·6363	1·00061	28·7537	88
3	·05234	·99863	·05241	19·0811	1·00137	19·1073	87
4	·06976	·99756	·06993	14·3007	1·00244	14·3356	86
5	·08716	·99619	·08749	11·4301	1·00382	11·4737	85
6	·10453	·99452	·10510	9·51236	1·00551	9·56677	84
7	·12187	·99255	·12278	8·14435	1·00751	8·20551	83
8	·13917	·99027	·14054	7·11537	1·00983	7·18530	82
9	·15643	·98769	·15838	6·31375	1·01246	6·39245	81
10	·17365	·98481	·17633	5·67128	1·01543	5·75877	80
11	·19081	·98163	·19438	5·14455	1·01872	5·24084	79
12	·20791	·97815	·21256	4·70463	1·02234	4·80973	78
13	·22495	·97437	·23087	4·33148	1·02630	4·44541	77
14	·24192	·97030	·24933	4·01078	1·03061	4·13356	76
15	·25882	·96593	·26795	3·73205	1·03528	3·86370	75
16	·27564	·96126	·28675	3·48741	1·04030	3·62796	74
17	·29237	·95630	·30573	3·27085	1·04569	3·42030	73
18	·30902	·95106	·32492	3·07768	1·05146	3·23607	72
19	·32557	·94552	·34433	2·90421	1·05762	3·07155	71
20	·34202	·93969	·36397	2·74748	1·06418	2·92380	70
21	·35837	·93358	·38386	2·60509	1·07114	2·79043	69
22	·37461	·92718	·40403	2·47509	1·07853	2·66947	68
23	·39073	·92050	·42447	2·35585	1·08636	2·55930	67
24	·40674	·91355	·44523	2·24604	1·09464	2·45859	66
25	·42262	90631	·46631	2·14451	1·10338	2·36620	65
26	·43837	·89879	·48773	2·05030	1·11260	2·28117	64
27	·45399	·89101	·50952	1·96261	1·12233	2·20269	63
28	·46947	·88295	·53171	1·88073	1·13257	2·13005	62
29	·48481	·87462	·55431	1·80405	1·14335	2·06266	61
30	·50000	·86603	·57735	1·73205	1·15470	2·00000	60
31	·51504	·85717	·60086	1·66428	1·16663	1·94160	59
32	·52992	·84805	·62487	1·60033	1·17918	1·88708	58
33	·54464	·83867	·64941	1·53986	1·19236	1·83608	57
34	·55919	·82904	·67451	1·48256	1·20622	1·78829	56
35	·57358	·81915	·70021	1·42815	1·22077	1·74345	55
36	·58778	·80902	·72654	1·37638	1·23607	1·70130	54
37	·60181	·79863	·75355	1·32704	1·25214	1·66164	53
38	·61566	·78801	·78129	1·27994	1·26902	1·62427	52
39	·62932	·77715	·80978	1·23490	1·28676	1·58902	51
40	·64279	·76604	·83910	1·19175	1 30541	1·55572	50
41	·65606	·75471	·86929	1·15037	1·32501	1·52425	49
42	·66913	·74314	·90040	1·11061	1·34563	1·49448	48
43	·68200	·73135	·93251	1·07237	1·36733	1·46628	47
44	·69466	·71934	·96569	1·03553	1·39016	1·43956	46
45	·70711	·70711	1·00000	1·00000	1·41421	1·41421	45
	Cosines.	Sines.	Cotangents.	Tangents	Cosecants.	Secants.	Deg.

"The preceding table is so arranged that for angles not exceeding 45 degrees, the sine, and cosine for any number of degrees will be found opposite to the proposed number in the left-hand column, and in the column under the appropriate word. When the number of degrees in the arc, or angle, exceeds 45 degrees, that number must be found in the right-hand column, and opposite to it in the column indicated by the appropriate word at the bottom of the table. Thus, the sine, and cosine of 36 degrees are ·58778, and ·80902 respectively; the tangent, and cotangent of 62 degrees are 1·88073, and ·53171 respectively; the radius of the table being unity, or 1. The taking of proportional parts for minutes can only be done correctly in those parts of the table where the differences between the successive sines, &c., run pretty uniformly. Suppose we want the natural sine of 20° 16′. The sine of 21 degrees is ·35837, that of 20 degrees is ·34202; their difference is 1635. This divided by 60 gives 27·25 for the proportional part due to 1 minute, and that again multiplied by 16 gives 436 for the proportional part for 16 minutes. Hence the sum of ·34202 and 436, or ·34638, is very nearly the sine of 20° 16′. But the operation may often be contracted by recollecting that 10 minutes are $\frac{1}{6}$, 15 minutes are $\frac{1}{4}$, 40 minutes are $\frac{2}{3}$ of a degree, and so on. Observe, also, that for cosines the results of the operations for proportional parts are to be *deducted* from the value of the required trigonometrical quantity in the preceding degree."

APPLICATION OF TRIGONOMETRY, WITHOUT LOGARITHMS, to the determination of Heights, and Distances.

Example 1.—Having measured a distance of 200 feet in a direct horizontal line from the bottom of a steeple, the angle of elevation of its top, taken at that distance, was found to be 47° 30′, from hence it is required to find the height of the steeple?

By deducting 47° 30′ from 90°, the angle opposite the given side will be found (42° 30′).

Then by *Case* 1. TRIGONOMETRY:—

As sine $\angle$ 42° 30′ : 200 :: sine $\angle$ 47° 30′ :
Or ·67556 : 200 :: ·73723 : 208·2, &c., height required.

By construction—

The triangle is constructed by making the side from a scale of equal parts, and laying down the angles from the protractor. Then by measuring the unknown parts by the same scale, the solution will be obtained.

Example 2.—Being on the side of a river, and requiring the distance to a house on the other side, 200 yards were measured in a straight line by the side of the river, and at each end of this base line the angles with the house were 68° 2′, and 73° 15′—required the distance from each end of the base line to the house?

The sum of the given angles (68° 2′ + 73° 15′) subtracted from 180° will give the third angle (38° 43′).

Then by *Case* 1. TRIGONOMETRY :—

As sine ∠ 38° 43′ : 200 : : sine ∠ 68° 2′
•62544 : 200 : : •92739 : 296•5 first distance required.
As sine ∠ 38° 43′ : 200 : : sine ∠ 73° 15′
•62544 : 200 : : •95753 : 306·1 second distance required.

Similarly to the preceding examples, HEIGHTS, AND DISTANCES may be rapidly (and for military purposes, sufficiently accurately) computed in the field, by means of the foregoing trigonometrical table, if proper attention is paid to the principles by which the unknown angles of triangles may be ascertained: a base line, and requisite angle, or angles, having been given.

It will, however, be necessary to use advantageously the methods in Cases 1, 2 (*vide* TRIGONOMETRY), and also the properties in the subsequent theorems, and corollaries.*

TABLE,

showing the reduction in feet, and decimals upon 100 *feet, for the following angles of elevation, and depression.*

Angle.	Reduction.	Angle.	Reduction.	Angle.	Reduction.
° ′		° ′		° ′	
3 0	·14	9 0	1·22	15 0	3·40
		9 30	1·38	15 30	3·64
4 0	·25	10 0	1·52	16 0	3·88
		10 30	1·68	16 30	4·12
5 0	·38	11 0	1·84	17 0	4·37
		11 30	2·01	17 30	4·63
6 0	·55	12 0	2·19	18 0	4·90
6 30	·65	12 30	2·37	18 30	5·17
7 0	·76	13 0	2·56	19 0	5·44
7 30	·86	13 30	2·77	19 30	5·74
8 0	·98	14 0	2·97	20 0	6·08
8 30	1·10	14 30	3·18	20 30	6·33

The reduction for 100 feet (from the above table) multiplied by the number of times 100 feet measured, will give the quantity to be subtracted from the measured length of an inclination, to reduce it to a horizontal position.

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* For further information on Surveying, and Reconnoitring, reference should be made to the highly-valued publication, entitled "A TREATISE ON MILITARY SURVEYING, INCLUDING SKETCHING IN THE FIELD, PLAN DRAWING, LEVELLING, MILITARY RECONNOISSANCE, &c.," by Lieut.-Colonel Basil Jackson, containing a full account of every surveying instrument, and the right adaptation of them.

TABLE,

showing the rate of inclination of inclined planes, for the following angles of elevation.

Angle.	One in	Angle.	One in	Angle.	One in
° ′		° ′		° ′	
0 15	228	3 30	17	7 0	8
0 30	114	3 45	16	7 30	7¼
0 45	76	4 0	15	8 0	7
1 0	56	4 15	14	9 0	6½
1 15	46	4 30	13	10 0	6
1 30	38	4 45	12	11 0	5¾
1 45	32	5 0	11½	12 0	5½
2 0	28	5 15	11	13 0	5
2 15	26	5 30	10½	14 0	4½
2 30	23	5 45	10	15 0	4
2 45	21	6 0	9½	16 0	3¾
3 0	19	6 30	9	17 0	3½
3 15	18	6 45	8½	18 0	3¼

SURVEYING, AND RECONNOITRING.

HEIGHTS, AND DISTANCES.

The accurate determination of heights, and distances of objects being required in various military operations, especially for the position of batteries, the following methods for their attainment will be found useful, when the requisite instruments are at hand; by frequent practice, the eye should, however, be enabled to determine, *nearly*, either the height of, or distance from any object.

HEIGHTS.

1.—BY MEANS OF A "POCKET SEXTANT,"

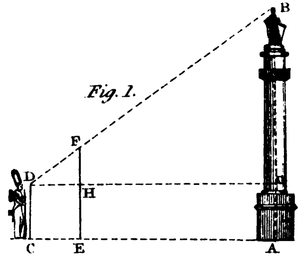
to ascertain the height of an object.

When the sextant is used for taking the height of objects, it is to be held vertically, and the quicksilvered part of the horizon glass will be on the left hand of the observer, or on the left part of the transparent glass. Altitudes are measured in the same manner as horizontal angles, for if we conceive the horizontal triangle A B C (*vide Plate* 2, *Fig*. 2, *page* 298) to be raised on its base A C with the angle C next to the observer, then the perpendicular A B becomes the height of the object B; and supposing the object to stand on a horizontal plane, then the ground and the object form the right angle at A; therefore, *if the object is accessible*, the sextant need only be set at any of the angles mentioned for distances (*vide Art.* DISTANCES), and walking backward on the

Plate 2.

HEIGHTS. No. 4.

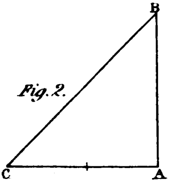
Fig. 1.



HEIGHTS. No. 5.

DISTANCES. No. 6.

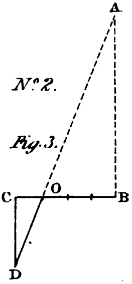
Fig. 2.



DISTANCES.

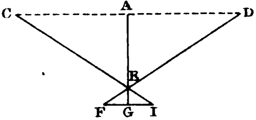
No. 2.

Fig. 3.



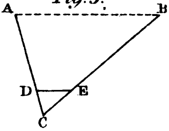
No. 3.

Fig. 4.



No. 4.

Fig. 5.



PRACTICAL GEOMETRY.

Fig. 1.

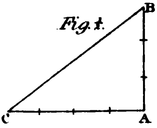


Fig. 21.

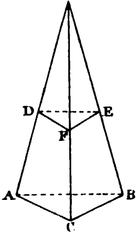
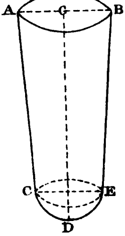


Fig. 22.



Surveying, and Reconnoitring.

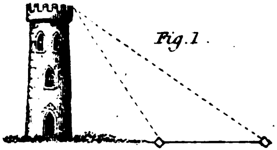


Fig. 1.

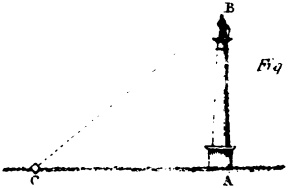


Fig. 2

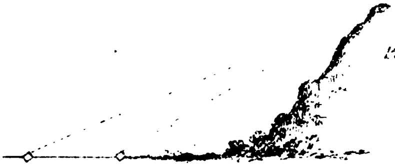


Fig. 3

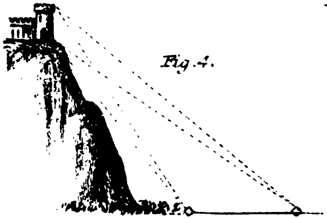


Fig. 4.

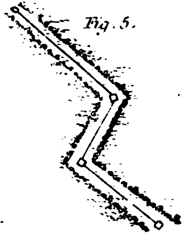


Fig. 5.

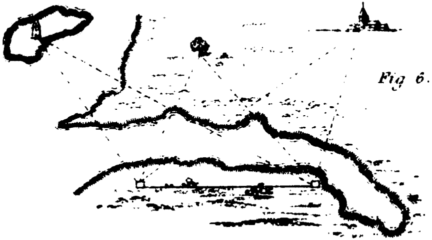


Fig. 6.

J. W. Lowry sc.

line A C until the top of the object is brought down to the height or the observer's eye from the ground, then the distance from where the observer stands to the object will be in the same proportion to its height as the base was to the distance. Then add the height of the eye from the ground, and the height of the object will be ascertained. If the object is not accessible, the angle must be taken, and calculated by trigonometry.

2.—BY MEANS OF A PORTABLE BAROMETER, AND THERMOMETER, *to ascertain the height of an object.*

Observe the altitude (B) of the mercurial column in inches, tenths, and hundredths, at the bottom of the hill, or other object, the height of which is required.

Observe, also, the altitude (b) of the mercurial column at the top of the object. Observe the temperature on Fahrenheit's thermometer at the times of the two barometrical observations, and take the mean between them. Then $55000 \times \frac{B-b}{B \times b}$ = the height of the hill in feet, for the temperature of 55 degrees on Fahrenheit. Add $\frac{1}{440}$ of this result for every degree which the mean temperature exceeds 55 degrees, and subtract as much for every degree below 55 degrees. This will be a good approximation when the height of the hill is below 2000 feet.

3.—BY MEANS OF THE RECONNOITRING PROTRACTOR,* *to measure the height of an inaccessible object.*

[*Plate*, SURVEYING, AND RECONNOITRING, *Fig.* 1.]

Place yourself at a convenient distance from the object whose height is required, taking care to have a good base line to the second station. Hold the protractor vertically, with a steady hand, the tube side uppermost, and bring the top of the object in a line with the centre of the tube. Allow the arm (or index) to vibrate freely, and, when steady, note the angular height of the object (shown by the edge of the index on the marginal scale of degrees). By the aid of points taken through the tube, or by pickets, then pace, or measure a base in a direct line from the object; and, when arrived at the second station, again note the angular height of the object.

Construction—

Set off the angles, and draw the respective lines, which, by their intersection, will determine the height of the perpendicular, to which the height of the protractor above the ground must be added for the altitude of the object. By using the scale of the measured base line, the height required will be ascertained, or it may be calculated by "TRIGONOMETRY, WITHOUT LOGARITHMS."—*Page* 338.

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* *Vide* page 347.

To measure the height of an accessible object.

[*Plate*, SURVEYING, AND RECONNOITRING, *Fig.* 2.]

At an appropriate distance from the object, take its angular height, and measure the distance to its base.

Construction—

Draw a line representing this distance, at one end of which draw another line at the angle found, and at the other erect a perpendicular; the intersection of these lines will determine the altitude of the object.

To measure the vertical height of a hill, or mountain.

[*Fig.* 3, *Plate*, SURVEYING, AND RECONNOITRING.]

From a station a short distance from the hill, take, and note down its angular height; then select a rear position for a base line, using the tube of the protractor to insure a straight direction; proceed to the requisite distance on the base, and again note the altitude of the hill.

Construction—

The intersection of lines drawn from each end of the base line, at the angles found, will determine the altitude; the perpendicular height of which, added to that of the protractor above the ground, will give the altitude required.

To measure the altitude of a tower, &c., on a height.

[*Fig.* 4, *Plate*, SURVEYING, AND RECONNOITRING.]

From the first station, near the base, take the altitude of the hill, and also that of the tower above it, and note down these angles; proceed to another station in a straight line with the former one, measuring its length, and again observe the angular height of the hill, and also that of the top of the tower.

Similarly to the previously described mode, ascertain, first, the height of the hill; second, the height of the hill, and tower; deduct the first calculation from the second, which will leave the height of the tower.

In all the foregoing cases the heights may be correctly ascertained by trigonometrical calculations (*vide* TRIGONOMETRY, WITHOUT LOGARITHMS, *page* 338).

4.—BY THE SHADOW OF THE OBJECT,

to ascertain the height.

Set up vertically a staff of known length, and measure the length of its shadow upon a horizontal, or other plane; measure also the length of the shadow of the object of which the altitude is required. Then, by the property of similar triangles,

As the length of the shadow of the staff
is to the altitude of the staff,
so is the length of the shadow of the object
to the altitude of the object.

5.—WHEN THERE IS NO SHADOW,

to ascertain the height.

Place a staff (equal in length to the height of the observer's eye) vertically at such a distance from the foot of the required altitude, that the observer, having laid himself upon his back, with his feet against the bottom of the stick, may see the top of the staff, and object in the same line. Then, by similar triangles, the height may be readily ascertained.

6.—BY MEANS OF THE TANGENT SCALE OF A GUN,

to ascertain the height of an object, the distance being known.

Lay the gun for the top of the object the height of which is required, then raise the tangent scale until the top of it, and the notch on the muzzle are in line with the bottom of the object: then, by similar triangles,

As the length of the gun
is to the length of the raised part of the tangent scale,
so is the distance from the gun to the object,
to the height required.

7.—BY MEANS OF TWO PICKETS,

to ascertain the height of an object.

[*Vide 2nd Plate*, HEIGHTS, AND DISTANCES, *Fig.* 1.]

Let two pickets C D (4 feet), E F (6 feet), be placed with their bases in the line C A passing through A the height required, and move them nearer to, or farther from each other, until the summit B of the object is seen in the same line as D, and F, the tops of the rods. Then, by the principles of similar triangles,

As $DH (= CE) : FH :: DG (= CA) : BG$.
To which add $AG = CD$ for the whole height AB.

Thus, supposing C E to be 6 feet, F H 2 feet, and C A 150 feet, the proportion will be,

As $6 : 2 :: 150 : 50$ feet.
Then $50 + CD$ will be the altitude required.

DISTANCES.

1.—BY MEANS OF THE SEXTANT,*

to find the distance from an object, whose height is known.

Let A B represent the height of the object; C your station; and C B the distance to be found.

Take the angle B C A with the sextant,* and note it in minutes;

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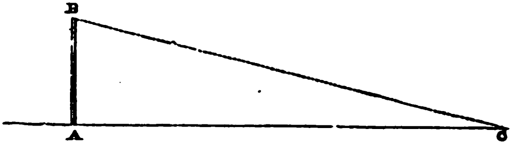
* Or Reconnoitring protractor.

then A B, in feet × 573 ÷ B C A, in minutes = A C in fathoms. Or A B in feet × 573 ÷ B C A, in minutes × 2 = A C in yards.



573 is a constant multiple.

This method requires no table of sines, &c., the number of minutes in the angle being used instead of the sine.

2.—BY MEANS OF A POCKET SEXTANT,

to measure inaccessible distances.

When used for taking the distance of objects, the sextant is to be held horizontally, and the quicksilvered part of the glass will be uppermost, or above the transparent part.

To ascertain the distance A B (*vide Plate* 2, *Fig.* 2), obtain, by observation, the direction A C perpendicular to A B, which is thus performed:—Set the instrument at 90°, and place yourself at the point A, with your right towards the point B; then look through the sextant, and direct a picket to be placed in the line A C at 100 yards, or feet, from you, so that the point B will appear right above it. Then set the sextant at 45°, and walk along the line towards C until you bring the points A, and B to coincide; the base and perpendicular will then be of equal length, and A C being known, or measured, the distance A B will also be ascertained. But if you cannot walk far enough to find angle C 45°, find it equal to 63° 26′, and then A C = $\frac{1}{2}$ A B; at 71° 34′ = $\frac{1}{3}$ A B; at 75° 58′ = $\frac{1}{4}$ A B; at 78° 41′ = $\frac{1}{5}$ A B; at 80° 32′ = $\frac{1}{6}$ A B; at 82° 52′ = $\frac{1}{8}$ A B; and at 84° 17′ the distance will be $\frac{1}{10}$ A B.

Should the object be far distant, it will be necessary to take a long base, and the side A B must be calculated, therefore, by trigonometry.

3.—BY MEANS OF THE PRISMATIC COMPASS,

to measure inaccessible distances.

Having fixed the instrument to the stand, place it over the station-point, spreading the legs so as to give sufficient firmness, and observing that the card is level enough to allow it to play freely; raise the prism by means of the slide, until the divisions of the compass-card are distinctly seen; then look through the slit, and turn the box round until the thread bisects the object whose distance is required; allow the card to settle, and the division on it, which coincides with the thread of the vane, will be the azimuth, or bearing of the object, reckoned from the north, or south point of the needle, when the card is divided into twice 180 degrees. The angular distance between any two objects will, of course, be the difference of their bearings; thus, suppose one to bear 15° N.E., and the other 165° S.E., the angular distance between them will be 150°.

In military sketching, the compass is often supported merely by the hands, using the little spring to check the vibrations of the card. In windy weather, the mean of these vibrations must be taken for the bearing sought.

The directions for Surveying, &c., &c., by means of "The Reconnoitring protractor," apply similarly to the "Prismatic compass."

4.—BY MEANS OF "THE RECONNOITRING PROTRACTOR,"

*to ascertain the distance from inaccessible objects.**

[*Plate*, SURVEYING, AND RECONNOITRING, *Fig.* 6.]

Select a good position for a base line; fix the protractor on the tripod at the first station, placing the instrument in a direct line between the first station, and the point selected for the second station. Direct the index consecutively at the objects, the relative distances of which are to be ascertained, and note correctly their respective angles. When the object is above the horizontal line, the sliding-sight must be sufficiently raised to take its bearing; and, should the object be below the level of the protractor, its angle may be taken by observation through the upper holes of the near sight; or the feet of the tripod may be adjusted, by raising, or sinking them in the ground, so that the index may be correctly directed to the object. Then proceed to the second station, measuring, or carefully pacing the base line, at the end of which fix the protractor in a straight line between the two stations; direct the index at the objects previously noted at the first station, taking their respective angles as before.

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* 1. The Reconnoitring protractor is not intended to supply the place of the Theodolite, or other expensive instruments, when very great accuracy is required in surveying, or in trigonometrical observations; but, in the hands of officers accustomed to the use of it, bearings may be rapidly taken, heights and distances ascertained, roads traversed, &c., &c., with sufficient accuracy for a military survey, or reconnoissance.

The protractor has a tripod, on which it is to be steadily fixed for taking angles, &c.; but the instrument can nevertheless be used without the tripod; and mounted officers may, after a little practice, make a reconnoissance with the protractor alone, especially if they are able to measure, or calculate the distance of base lines, by the length of the paces of their horses.

2. A survey, &c., may be very rapidly taken in the field, by laying drawing-paper on the face of the protractor, under the marginal scale, fixing it firmly by means of drawing-pins in the sides, and using, at the first station, the edge of the index as a ruler to set off on the paper, at once, by observation through the sights, the angles of the objects whose distance is required; drawing a base line parallel to the tube side of the instrument, and also lines at the angles found. At the second station, the paper must be moved a few inches towards the first station, and the index is to be directed to the objects, as before, and lines are to be produced until they intersect those drawn at the first station: thus the position of the objects will be obtained; and, by using the scale on the index for the length drawn for the measured base line, as well as for the lines directed to the objects, their respective distances will be ascertained.

3. The reconnoitring protractor, and all other instruments for surveying, &c., &c., can be readily obtained from Messrs. Elliott, 30, Strand, London.

Construction—

Draw the base of the length required, according to the scale; from each end of which set off the angles found, and draw the lines required; the intersection of these will determine the position of the several objects, and their relative distances may be ascertained by measurement on the scale of the base line; or they may be calculated trigonometrically.

5.—BY MEANS OF TWO PICKETS,

to ascertain the distance from an object.

Take two pickets of unequal lengths, drive the shortest into the ground, say close to the edge of a river; measure some paces back from it, and drive in the other, till you find, by looking over the tops of both, that your sight cuts the opposite bank. Pull up the first picket, measure the same distance from the second in any direction the most horizontal, and drive it as deep in the ground as before. Then, if you look over them again, and observe where the line of sight falls, or terminates, you will have the distance required. This method is only applicable to short distances.

6.—*To ascertain the distance of the object* A *from* B.

[*Vide Plate* 2, *Fig.* 3.]

Place a picket at B, and another at C at a few yards' distance, making A B C a right angle, or B C perpendicular to A B.* Divide B C into 4, 5, or any number of equal parts, make another similar angle at C in a direction from the object, and walk along the line C D until you bring yourself in a line with the object A, and any of the divisions (say O) of the line B C. Then (having measured C D) as C O : C D : : B O : B A.

Or, as 10 : 53 : : 30 : 159 yards.

7.—*To find the distance between two objects,* C, *and* D.

[*Vide Plate* 2, *Fig.* 4.]

From any point A, taken in the line C D, erect the perpendicular A E, on which set off from A to E 40 yards, set off from E to G, in the prolongation of A E, 10 yards, at G, raise the perpendicular G F, and produce it towards I, plant pickets at E, and G, then move with another picket on G F, till F is in a line with E, and D; and on the prolongation of the perpendicular F G place another picket at I in the line with E, and C : measure F I (54 yards), then—

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* To erect a perpendicular, *vide* "Practical Geometry."

as G E : A E :: F I : C D;

Or, as 10 : 40 :: 54 : 216 yards.

8.—*To find the inaccessible length*, A, B, *of the front of a fortification.*

[*Plate* 2, *Fig*. 5.]

Plant a picket at C, from whence both points may be seen; find the lengths C A, C B (by the method in No. 5); make C E one-fourth, or any part of C B, and make C D bear the same proportion to C A: measure D E; then

as C D : D E :: C A : A B.

Nearly in the same manner the distance from B to A may be ascertained, when the point B is accessible; for having measured the line C B, and made the angle C E D equal to C B A, the proportion will be as C E : D E :: C B : B A.

9.—BY MEANS OF THE TANGENT SCALE OF A GUN,

to ascertain the distance, the height of the object at the required distance being known.

Lay the gun by the line of metal for the top of the object; then raise the tangent scale till the top of it and the notch on the muzzle are in line with the foot of the object, and note what length of scale is required.

Then,—by similar triangles—
As the length of the raised part of the tangent scale
is to the length of the gun;
so is the height of the distant object
to the distance required.

Thus, supposing the height of the object to be 9 feet, the length of that part of the tangent scale which is raised, 3 inches, and of the gun 6 feet, the proportion will be—

As 3 : 72 :: 108 : 2592 inches, or 216 feet.

10.—BY MEANS OF THE PEAK OF A CAP,

to measure the breadth of a river.

Place yourself at the edge of one bank, and lower the peak of your cap till you find the edge of it cut the other bank, then steady your head by placing your hand under your chin, and turn round gently to some level spot of ground on your side of the river, and observe where your eyes, and the edge of the peak again meet the ground; measure the distance, which will be *nearly* the breadth of the river.

11.—BY THE REPORT OF FIRE-ARMS, TO ASCERTAIN THE DISTANCE OF ANY OBJECT, *vide* SOUND, *page* 351.†

12.—BY EYE-SIGHT, *to estimate distances, in the field.*

Good eyesight recognises masses of troops at 1700 yards; beyond this distance the glitter of arms may be observed. At 1300 yards infantry may be distinguished from cavalry, and the movement of troops may be seen; the horses of cavalry are not, however, quite distinct, but that the men are on horseback is clear. A single individual detached from the rest of the corps may be seen at 1000 yards, but his head does not appear as a round ball until he has approached up to 700 yards; at which distance white cross-belts, and white trousers may be seen. At 500 yards the face may be observed as a light coloured spot; the head, body, arms, and their movements, as well as the uniform, and the firelocks (when bright barrels) can be made out. At between 200 and 250 yards all parts of the body are clearly visible, the details of the uniform are tolerably clear, and the officers may be distinguished from the men.

Vide "UNITED SERVICE MAGAZINE."—No. CCCXXXI.

BY MEANS OF THE RECONNOITRING PROTRACTOR,

to traverse roads.

[*Plate*, SURVEYING, AND RECONNOITRING, *Fig.* 5.]

Fix the protractor on the tripod at the first station, placing it so that the side tube may be in a direct line with the intended second station. From each end of the tube observe the objects in sight (or place pickets) in order to secure a straight line in pacing, or measuring, from the first to the second station. Mark the distance between the stations, and place the protractor, by means of the tube, in a direct line with the first station. Then select the third station, and direct the arm or index correctly to it (using the upper holes of the near sight for a declivity, or raising the sliding sight for an ascent); note the angle thus found, and notice the objects in front, and rear (if any, if not, place pickets) for points to enable you to pace towards, and work with accuracy at the third station. Select station 4, place the tube in line with the third, and second stations; note the bearing of No. 4, and pace the distance to it. Proceed thus from station to station, entering the angles, and distances in your note-book, as well as the offsets (which must also be carefully measured) from the lines taken, until the survey is completed.

The traversing may be performed in a similar manner with the Prismatic compass, &c.

Construction—

The day's work will be easily plotted on paper, by setting off the angles found, and drawing lines for the measured distances, according to scale.

SOUND.

The movement communicated to the particles of air by the vibrations of a sonorous body is the cause of the sensation of sound; and it is because the particles are driven from the point of vibration in every direction, as from a centre, that the sound is perceived at once, everywhere within the surface of a sphere of a certain extent.

The velocity of sound; or the space through which it is propagated in a given time, has been differently estimated by authors who have written on this subject. Roberval states it to be at the rate of 560 feet in a second; Gassendus at 1473; Mersenne at 1474; Duhamel at 1338; Newton at 960; Derham, in whose measure Flamsteed and Halley acquiesce, at 1142. By accounts in the Memoirs of the Royal Academy of Sciences, at Paris, 1738, when cannon were fired at various distances, under many varieties of weather, wind, and other circumstances, and where the measures of the different places had been settled with the utmost exactness, it was found that sound was propagated, on a medium, at the rate of 1038 French feet in a second of time, which is equivalent to 1107 *English feet*, the French foot being in proportion to the English as 15 to 16.

From various experiments made with great care by Dr. O. Gregory, it has been found that sound flies through the air uniformly at the rate of about 1100 feet per second, when the air is quiescent, and at a medium temperature. At the temperature of freezing, or a little below, the velocity is about 1120. The approximate velocities under different temperatures may be found by adding to 1100 *half a foot* for every degree on Fahrenheit's thermometer above the freezing point. The mean velocity may be taken at 370 yards per second, or a mile in $4\frac{7}{9}$ second. Hence, multiplying any time employed by sound in moving by 370, will give the corresponding space in yards, or dividing any space in yards by 370 will give the time which sound will occupy in passing uniformly over that space. If the wind blow briskly, as at the rate of 20 to 60 feet per second, in the direction in which the sound moves, the velocity of the sound will be proportionally augmented; if the direction of the wind is opposed to that of the sound, the difference of their velocities must be employed. The velocity of sound is not affected by its intensity, the smallest sound moving as rapidly as the loudest.

To ascertain the Distance of any object by the report of fire arms.†

Multiply the number of seconds which elapse between the time of seeing the flash, and hearing the report by 1100, and the product will be the distance in feet, with sufficient accuracy for ordinary purposes. If greater accuracy be required, this rule must be modified, on account of the velocity, and direction of the wind, and state of the thermometer.

Sound will be louder in proportion to the condensation of the air. Water is one of the greatest conductors of sound; it can be heard on water nearly twice as far as upon land.

RECONNOITRING.*

The following *Memoranda* will serve to point out the principal objects to which an officer employed on the important duty of Reconnoitring should direct his attention.

1. *The particular nature of each district, &c. of country; and its productions.*

Information should be obtained, and noted on the following subjects. What parts of the country are mountainous, or hilly, and what are level; whether the hills are steep, broken by rocky ground, rise by gradual and easy slopes, or if the ground is undulated only in gentle swells. In what directions the ridges run, and which are their steepest sides. The nature and extent of their valleys, ravines, where they originate, in what direction they run, whether difficult of access, or to be easily passed. Whether the country is barren, or cultivated, and what is the kind of cultivation. If a country of pasturage, whether it is grazed by cattle, by sheep, or by horses, and in what numbers; what parts of the country are open, and what are enclosed, and the description of the enclosures. What parts of the country are wooded, and with what species of trees. What the nature of the soil. What is the nature of the country, in reference to the operations of troops, what parts of it are favourable for the acting of cavalry, and what for infantry only.

2. *The rivers, minor streams, and canals.*

The sources of *Rivers*, and the direction of their course, whether they are rapid, or otherwise; their breadth and depth, and what variations they are subject to, at different seasons of the year; the nature of their channels, and of their banks, whether rocky, gravelly, sandy, or muddy; of easy, or of difficult access.

Bridges.

The Bridges across rivers whether of stone, or of wood, their breadth, and length, if accessible to Artillery, and capable of bearing its weight. The nature of the *Fords*, if always passable, or at certain times, and seasons only; whether their situations change (a ford should not exceed, in depth, 3 feet for infantry, 4 feet for cavalry, and 2½ feet for artillery). What rivers are navigable, and from and to what points, and by what description of vessels, or boats.

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* Extracted from "A Treatise on Military Surveying, including Sketching in the Field, Plan Drawing, Levelling, Military Reconnoissance, &c.," by Lieut.-Colonel Basil Jackson.

Ferries.

Their breadth, and the nature of their landing-place on each side; what description of boats are used at them, how many men, horses, or carriages, each boat is capable of conveying, how much time the passage requires, and in what manner it is performed.

Canals.

Their course, breadth, and depth, the nature of the traffic carried on upon them, the number of the boats usually to be found at different places, and the nature, and dimensions of the boats, &c., navigated.

Lakes, and islets of the sea.

Their situation, extent, and boundaries, what description of vessels can navigate them, &c.

Marshes.

Their situation, and extent, whether passable for troops in any part: and if they continue throughout the year, or exist only during the wet season.

3. *Population, resources, accommodation for Troops, &c.*

The size of towns, and villages, and the number of their inhabitants and whether well supplied with provisions, or not. The number of houses, churches, convents, or other public buildings, whether the houses are large, or small, what number of troops could be accommodated in private houses, and what in public buildings; what stabling there is, or other cover for horses; if the town is walled, or open, favourably situated for defence, or otherwise; if capable of being strengthened, and by what means. Plans, or sketches of walled towns, defensible villages, or detached buildings should always accompany the reports upon them. The number of carriages, horses, mules, and draught oxen in possession of each town, village, &c., should be stated, and what mills are in the town, or vicinity, and whether turned by wind, or water, what number of bakehouses, and quantity of bread they can produce in a given time; whether the place is unhealthy, or not, if it be, whether it is in general unhealthy, or only so at particular seasons.

Roads.

Particular information must be obtained respecting the roads, in the description of which it is impossible to be too minute. Whether the road is fit for Artillery, wheel carriages, Cavalry, or for Infantry only, over what description of soil it passes, and to what injuries it is liable in bad weather: whether it is easily repairable, or not; whether materials are to be found in the neighbourhood, whether any great improvement can be made in the general direction of any part of the road, by adopting a new line, &c. Particular attention should be paid to the ascents, and descents upon the road, whether they are gradual, or abrupt, rugged, or stony, having short turns, or other difficulties. The ferries, bridges, fords, &c., met with upon the road should be particularly described: the possibility of obstructing, or breaking up the road so as to prevent its being used by the enemy, or of destroying the bridges, or fords should be stated. The distances of the places along the road should be given, both in the measures of the country, and in English miles. The time required to travel the different distances (at the ordinary walk of a man, or pace of a horse) should also be stated. The places to the right, and left, near the road, should be mentioned; their distances from the road, and at what points the communications to them strike off. Whether there are any railroads, and what facilities they offer for the rapid transport of troops, artillery, provisions, &c.

Camps, and Positions.

All strong passes, posts, or more extensive positions, which present themselves either upon the line of a road, or in any other situation, as also all places favourable for encamping, or bivouacking troops should be particularly described, their situation, extent, facility of access, nature of soil, supply of water at all seasons, quantity and kind of wood, &c.

A sketch of the ground should always accompany these reports. Sketches of positions should never be made upon a smaller scale than four inches to an English mile. More general sketches may be made upon a scale of two inches to a mile, and tracings of roads upon a scale of one inch to a mile. In all Reports, officers should state distinctly what parts of the information they contain rest upon their own personal examination of the objects in question, and what upon the authority of others, and in the latter case, they should mention the source of their information.

THE END.

LONDON: PRINTED BY WILLIAM CLOWES AND SONS, STAMFORD STREET.